DECEMBER 1961
Volume 199 Part 4

FABER FABRUM ADJUVET

Established 1869

Incorporated by Royal Charter 1899

A full list of contents is given on the Title Page (see page 47 of the Advertisement Section)

JOURNAL OF THE IRON AND STEEL INSTITUTE

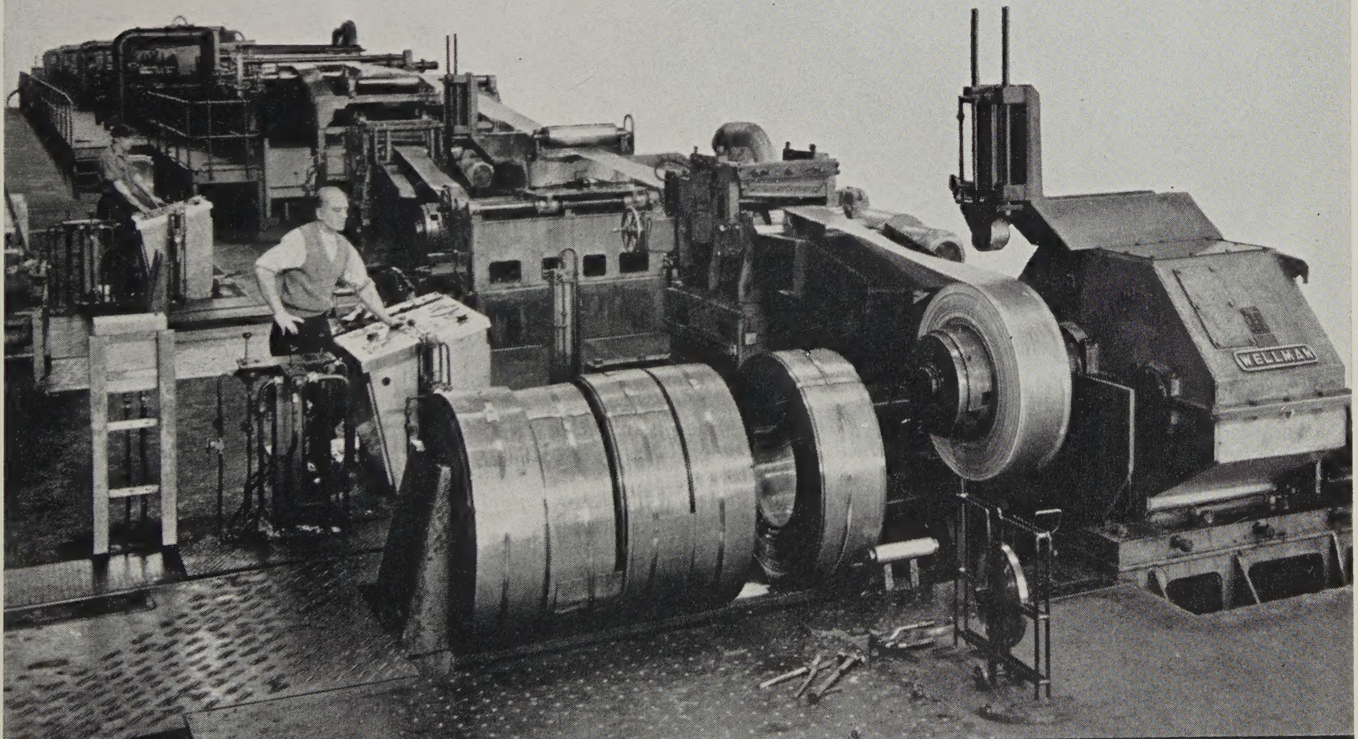
PRICE TWENTY-FIVE SHILLINGS

WELLMAN

Auxiliary
Rolling Mill Equipment

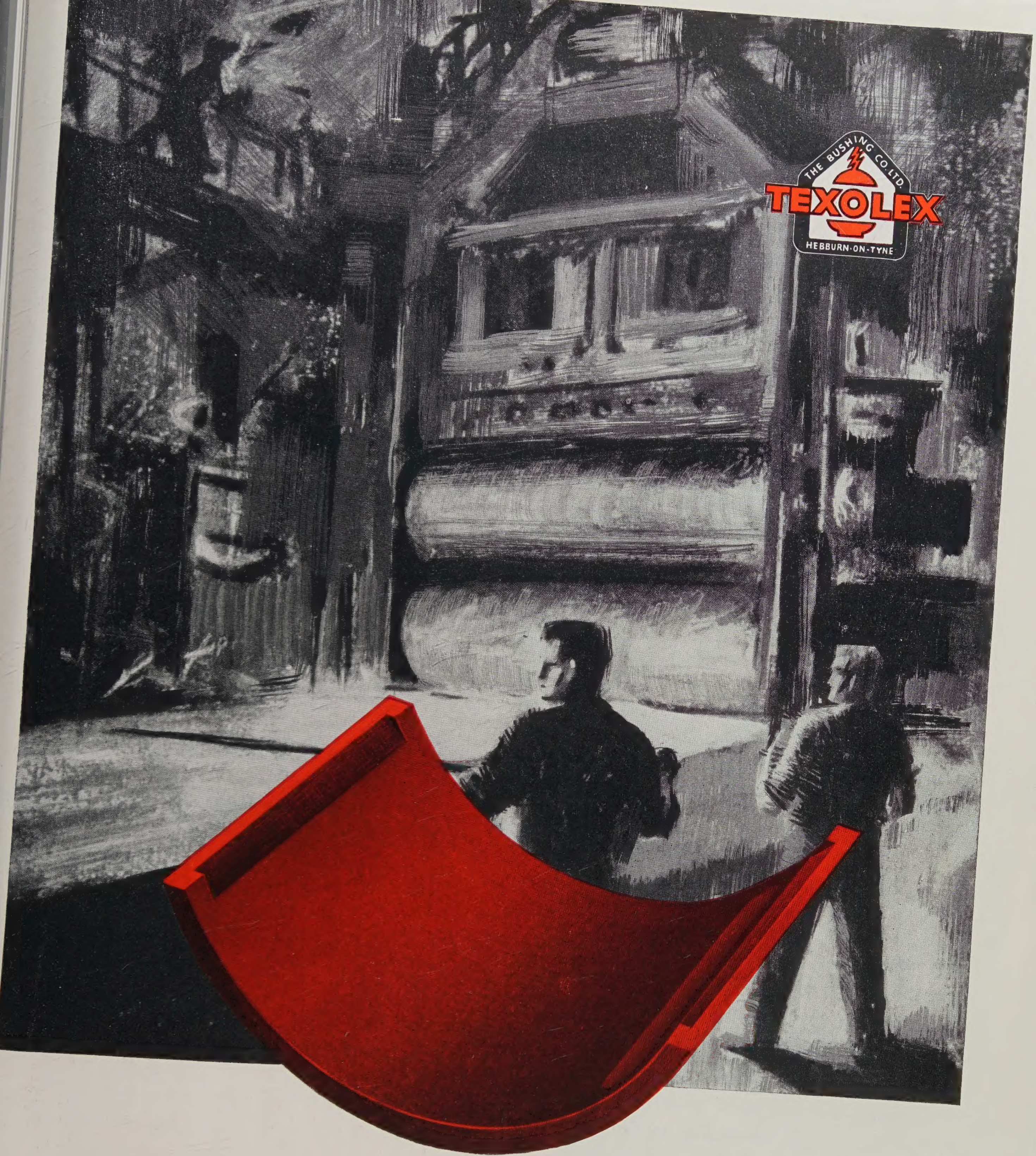
Below is illustrated the exit end of a Wellman Multi-Strand Continuous Pickle Line, for processing low carbon and mild steel hot rolled strip, installed at the Works of a large Sheffield manufacturer. The line is at present operating with two strands, but will ultimately be arranged for four-strand simultaneous processing.

This is one of the numerous Wellman installations in both the United Kingdom and Overseas, designed for the continuous processing of low carbon, mild, silicon and stainless steels in a wide variety of gauges and widths.



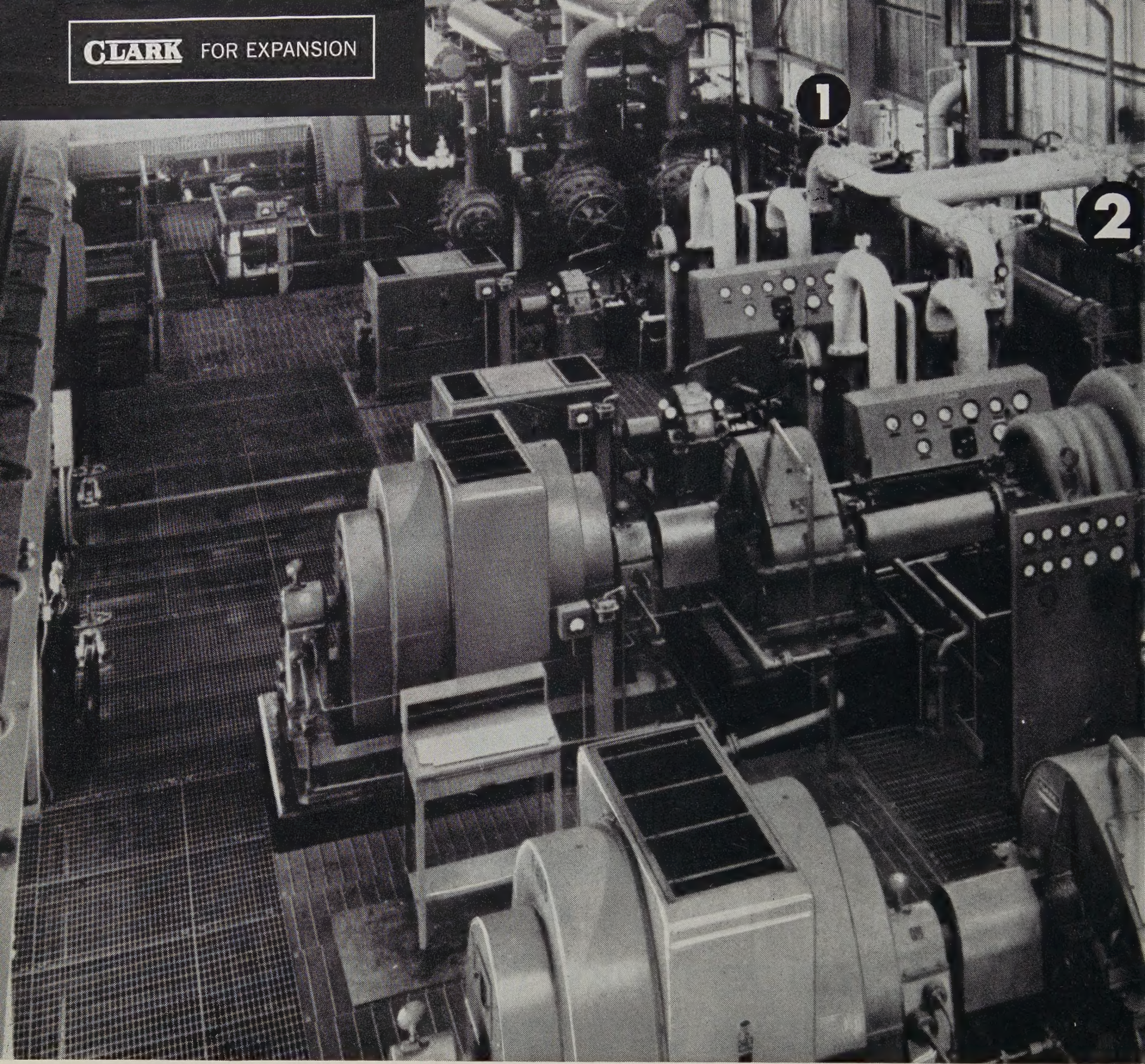
THE WELLMAN SMITH OWEN ENGINEERING CORPORATION LTD.

PARNELL HOUSE, WILTON ROAD, LONDON, S.W.1 WORKS: DARLASTON, South Staffs, & BELFAST.


THE BUSHING CO. LTD
TEXOLEX
HEBBURN-ON-TYNE


"H·T1"

CLARK FOR EXPANSION



MAXIMUM-THROUGHPUT, MINIMUM-PLANT

Air Separation for Steelmaking Oxygen

To meet growing competition, steelmakers are going all out to reduce production costs . . . with oxygen.

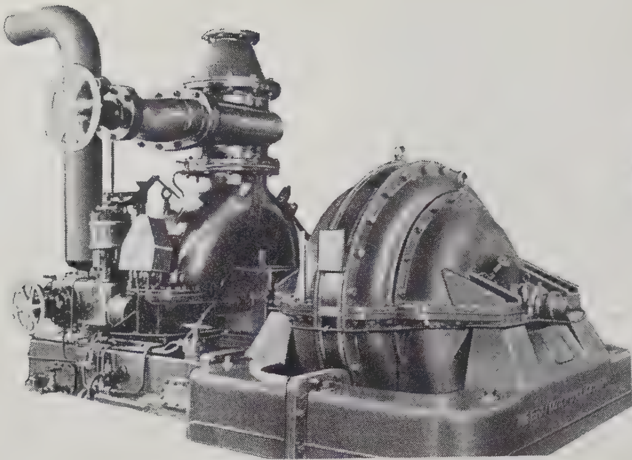
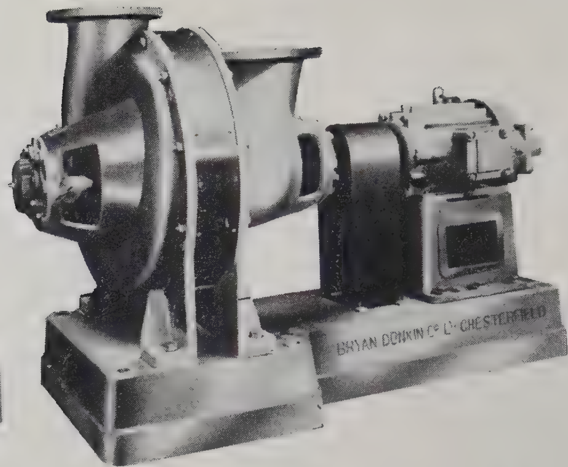
By 1965, say forecasters, new basic oxygen steel plants will be producing more than 10% of the world's steel . . . at savings as high as 30% over former methods. Open hearth producers, too, are demanding big and increasing quantities of oxygen . . . making higher grade steels at lower c

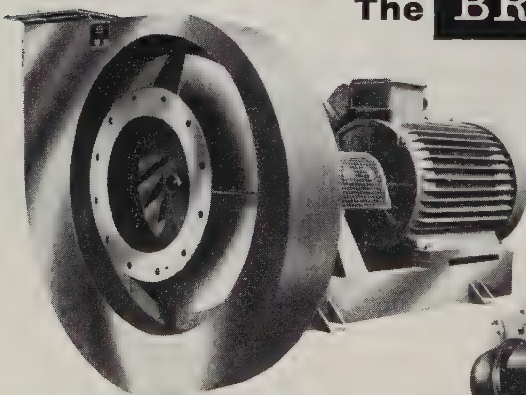
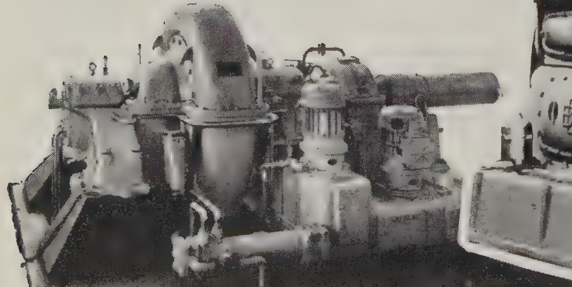
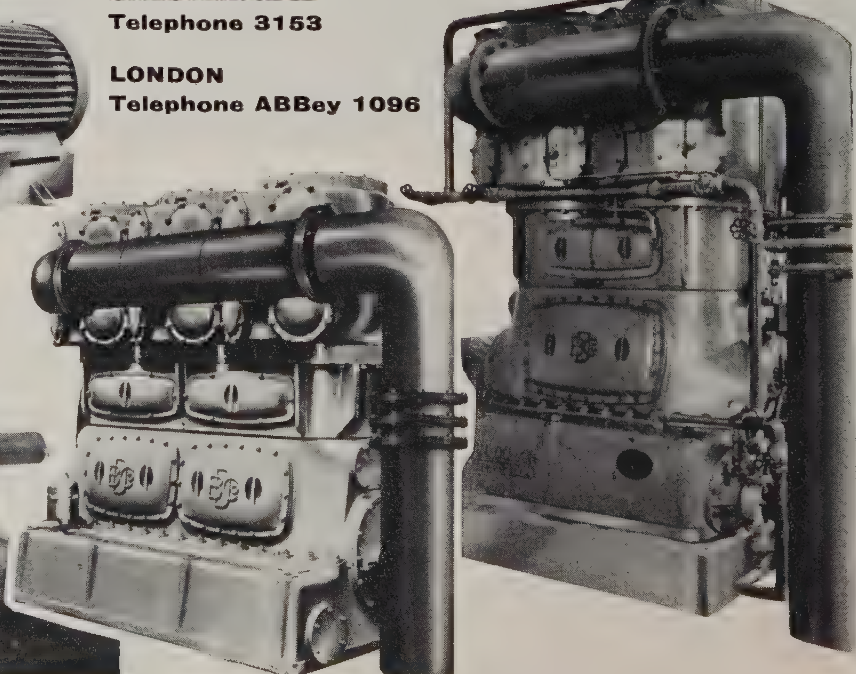
Most Convenient Source...Air

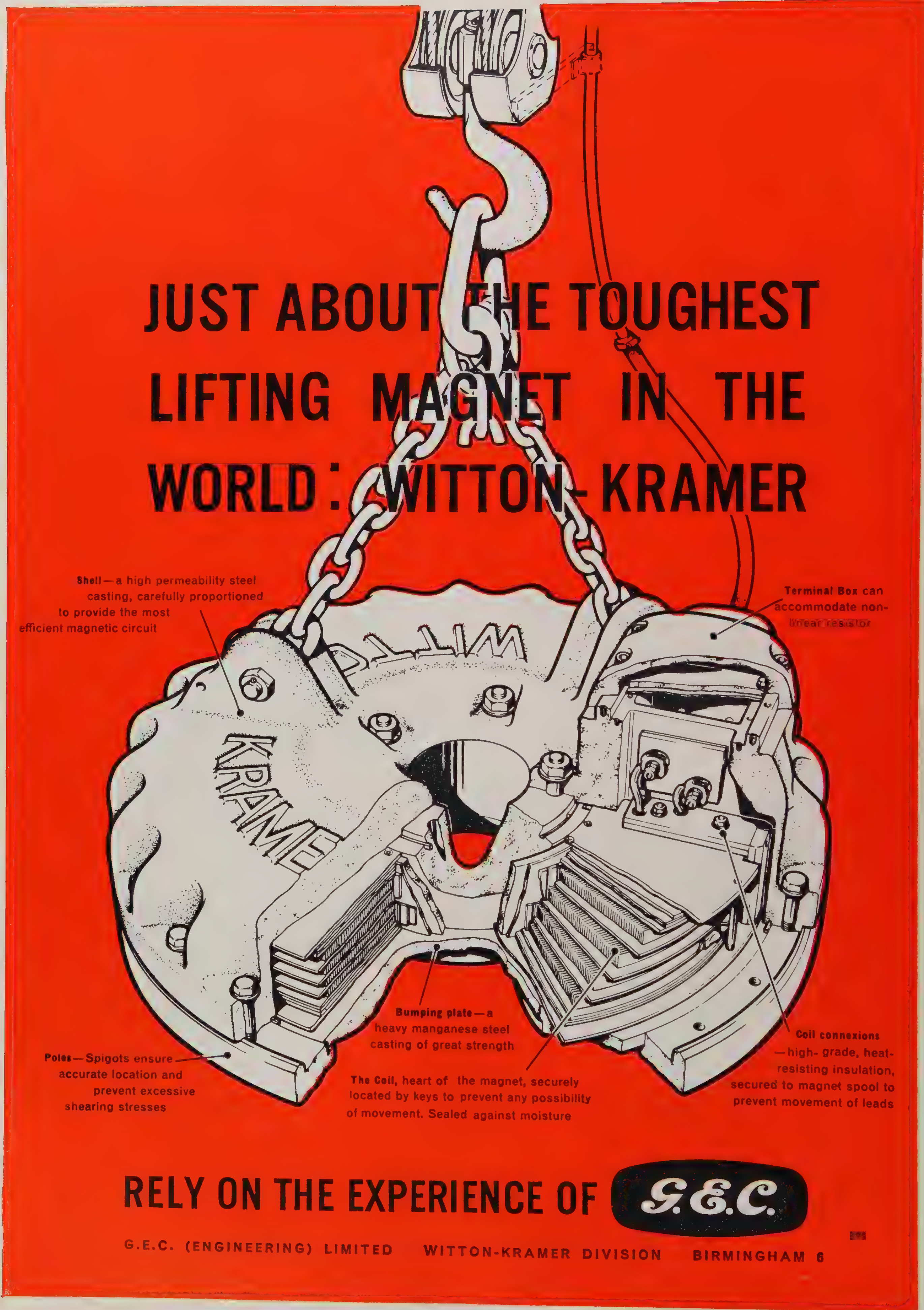
Steelmakers are taking their oxygen f air, right at the point of use. To keep t oxygen costs per ton of steel at a minin many of them (or their suppliers) advantage of the advanced design of C Compressors.

On the average, air separation systems using Cla Compressors require from 25 to 33⅓% less pla area than systems using other compressors of co parable output...with impressive savings in capi investment and in operating and maintenance cos

Here is a specific! The two Clark *Iso* centrifugal compressors for handling " pound" air shown (3) in the foregrou the picture above require 40% less space than comparable machines and less than compound centrifugals e nally intercooled. And far less piping


BRYAN DONKIN Cº Lᴰ CHESTERFIELD



JUST ABOUT THE TOUGHEST LIFTING MAGNET IN THE WORLD: WITTON-KRAMER
Shell—a high permeability steel casting, carefully proportioned to provide the most efficient magnetic circuit
Terminal Box can accommodate non-linear resistor
Poles—Spigots ensure accurate location and prevent excessive shearing stresses
Bumping plate—a heavy manganese steel casting of great strength
The Coil, heart of the magnet, securely located by keys to prevent any possibility of movement. Sealed against moisture
Coil connexions—high-grade, heat-resisting insulation, secured to magnet spool to prevent movement of leads
RELY ON THE EXPERIENCE OF G.E.C.
G.E.C. (ENGINEERING) LIMITED WITTON-KRAMER DIVISION BIRMINGHAM 6

WARNER pigs for

analytical accuracy

Accuracy of analysis within the closest limits is one of the many advantages which Warner Pig Iron offers to the High Duty Foundry.

Analysis Certificate DATED 15th 19..

We hereby certify that the analysis of **Warner Refined High Duty Pig Iron, coloured Red** forwarded to **Messrs. High Duty Foundries Ltd., Ferrous Works, Derby** on the **15th September, 1961** is as follows :—

Order No.	Ref	Wagon	T.C	Si	Mn	S	P	Ni	Cr.	Mo	Cu
	..28	PXA 492	2.76	1.92	1.03	.028	.135	1.07	-	.32	-

fitness for purpose

..arner Pig Iron is available in many grades, ..ch of which is designed to provide ..e required physical properties in the casting.

	TENSILE			TRANSVERSE				
Grade	Gauge dia.	Area	Minimum tensile strength	Nominal dia. of test bar as cast	Distance between support centres	Minimum breaking load	Transverse rupture stress	D
	in.	sq. in.	tons/ sq. in.	in.	in.	lb	tons/ sq. in.	
	..799	0·125	22·0	0·6	9	725	34·	
		·25(					33	

prompt delivery

Delivery according to schedule is a major part of the Warner Service, and urgent requirements are invariably met.

CARGO FLEET

MIDDLESBROUGH

ROAD TRANSPORT DELIVERY NOTE

Date **15th September, 1961**

Messrs. **High Duty Foundries Ltd.,**

Ferrous Works,

Derby.

WARNER WARNER WARNER

PIONEERS OF REFINED PIG IRON

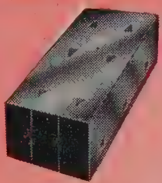
WARNER & CO LTD MIDDLESBROUGH

A UNIQUE CASE...

...Co-moulded under high pressure, the brick and four-sided casing form an integral unit ensuring absolute accuracy of shape and size with maximum volume stability during use. Manufactured in a full range from 100% chrome ore to 100% Magnesite.

GR FERROCLAD

METAL-CASED
CHEMICALLY BONDED
BASIC BRICKS

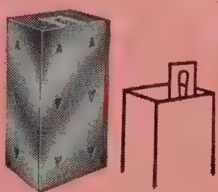


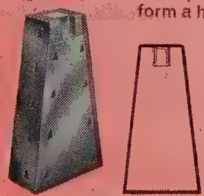
FERROCLAD 'EE' BRICKS

Divided internally by two plates placed lengthwise. This system reduces flaking and spalling to a minimum and can be applied to all Ferroclad shapes and sizes.

TABHANGER SUSPENSION

Bricks supplied with a special stainless steel tab co-moulded with the brick are embedded into the surface of the top face. The tab may be bent out at right angles to the top face to form a hanger.





FERROCLIP SUSPENSION

Allows the brick to be suspended from the end. The Ferroclip hanger slot may be moulded into any roof or wall shape.

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for everything in Refractories

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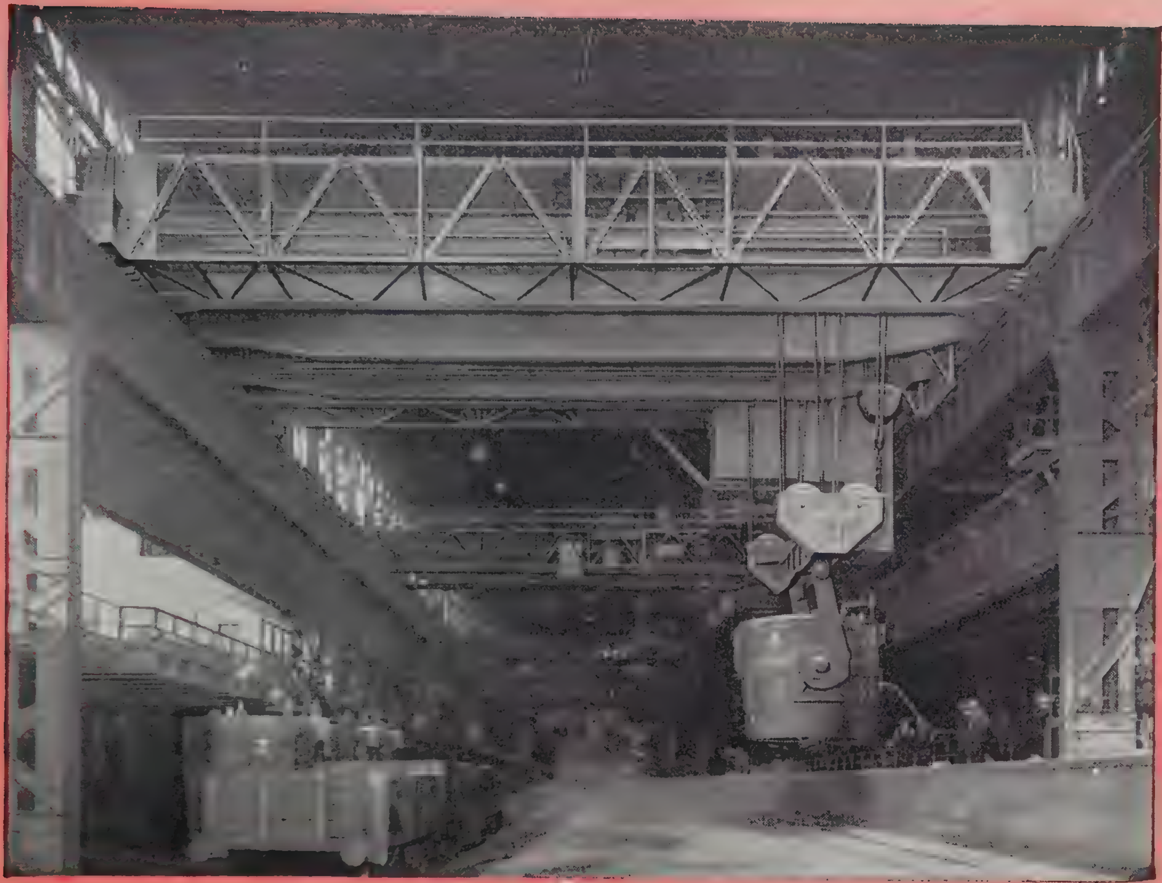
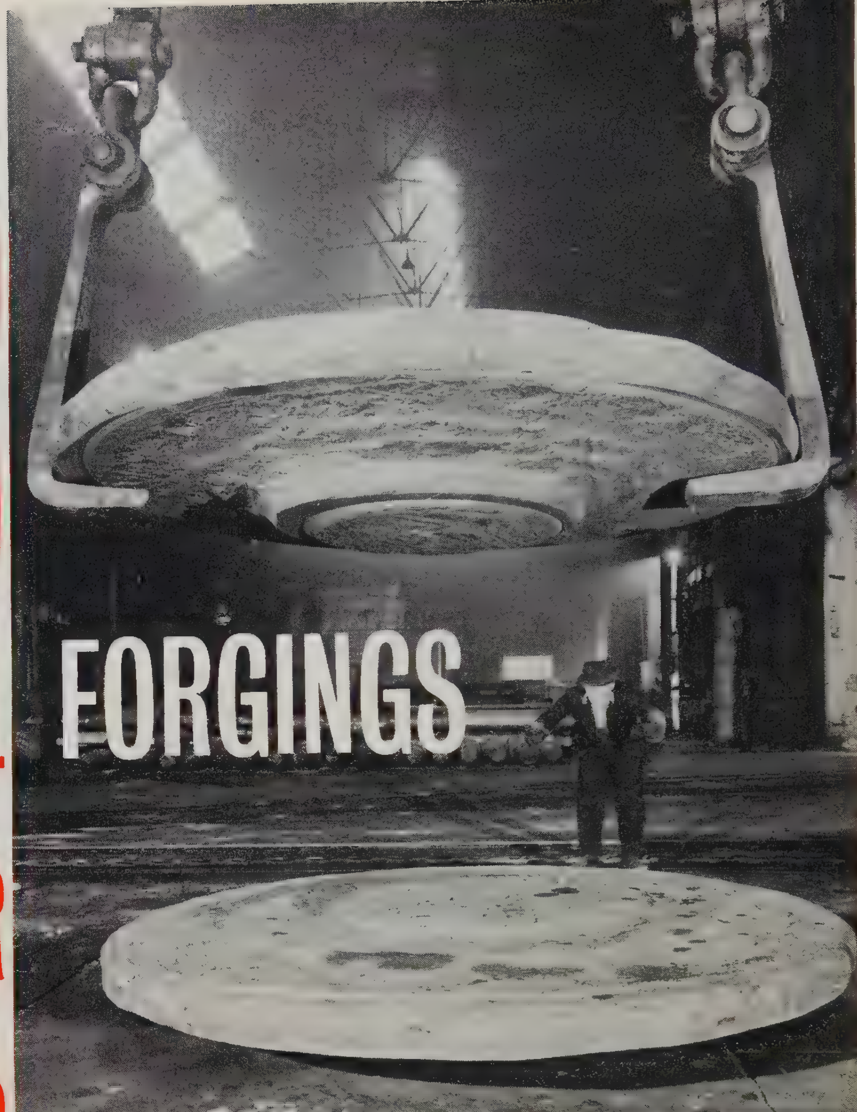
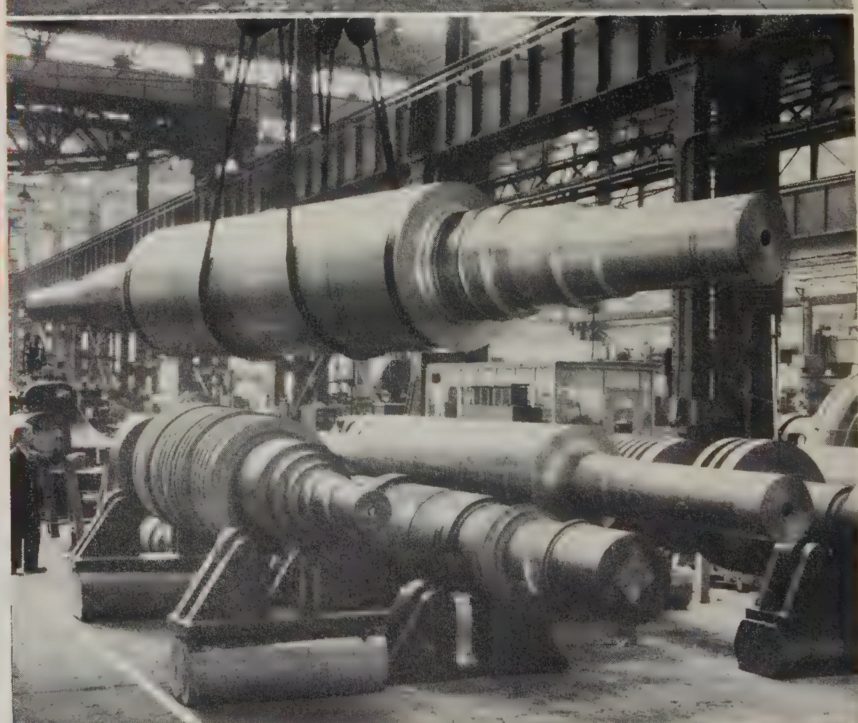


FIRTH BROWN STEEL FORGINGS FOR POWER GENERATION



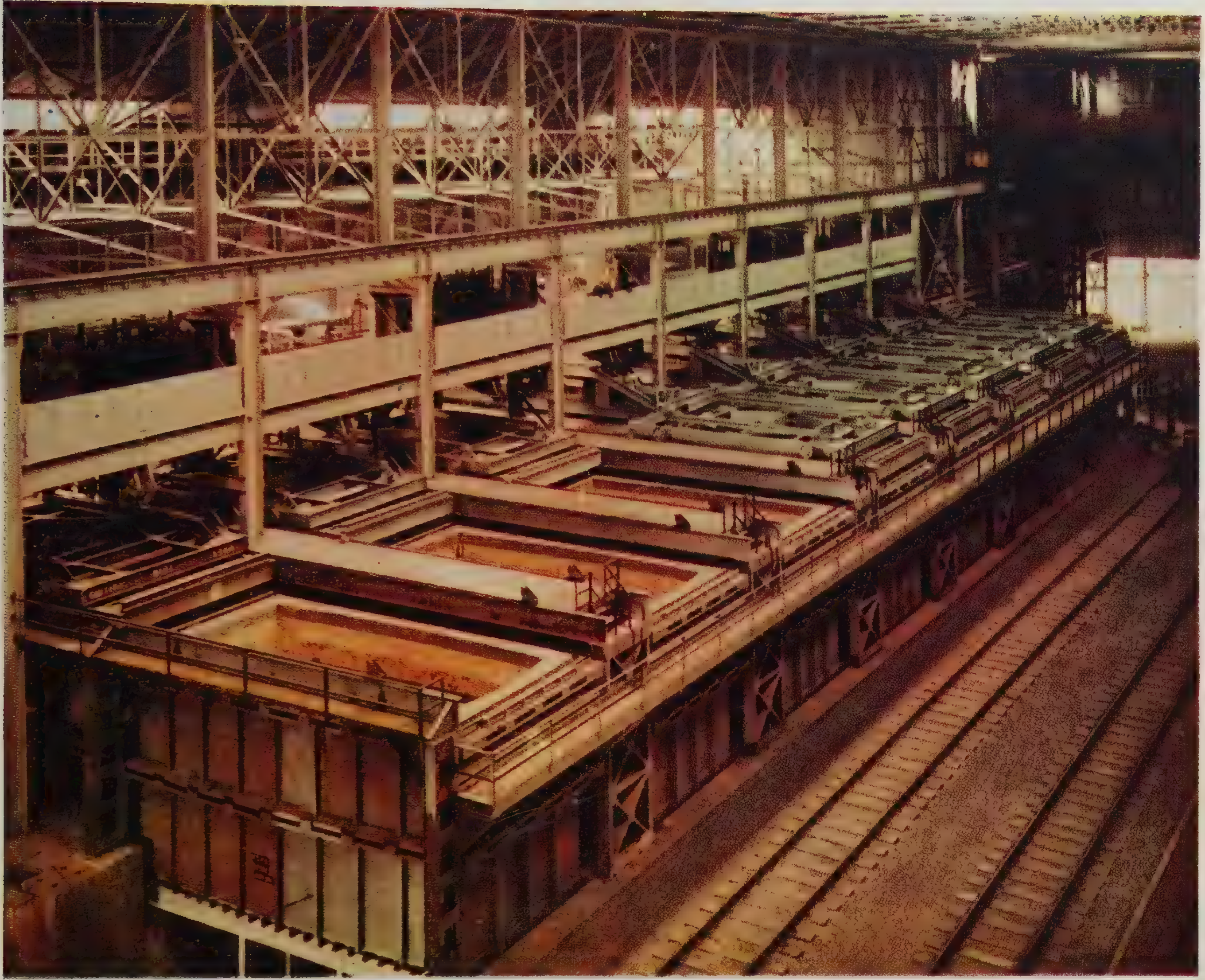


Firth Brown

ALLOY STEELMAKERS
FORGEMASTERS
STEEL FOUNDERS
HEAVY ENGINEERS

ATLAS WORKS · SHEFFIELD · ENGLAND

AERIAL VIEW OF A SECTION OF IRLAM WORKS. Photograph by Aero Pictorial Ltd.



SALEM-BROSIUS

Top Photograph —
Eight Rectangular Soaking Pits each with a holding capacity of 120 tons — the latest of thirty pits supplied by Salem-Brosius (England) Limited to the same Customer.

Since 1939 we have designed and built a total of ninety-five Soaking Pits in the United Kingdom and on the Continent — forty-four of our versatile Circular type and fifty-one of the Rectangular one way fired type.

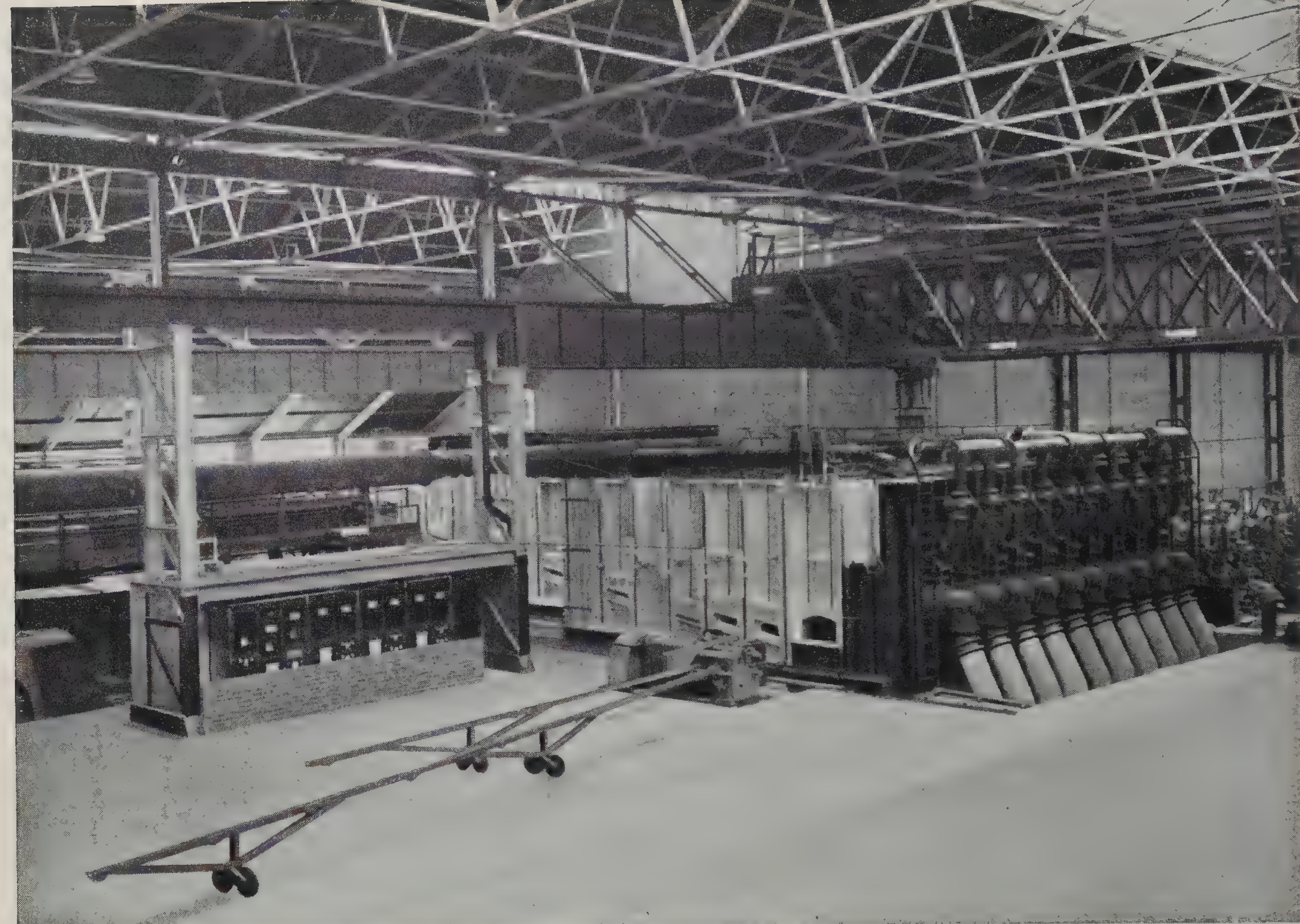
Bottom Photograph —
Standard range of Rotary Hearth Furnaces for forging and general heat treatment. Capacities 650 to 6,500 lb/hr. Uniform continuous heating with maximum economy in operation.

SALEM BROSIUS (ENGLAND) LTD.

MILFORD HOUSE · MILFORD · Nr. DERBY
Phone: Duffield 2271. Grams: Keener Belper

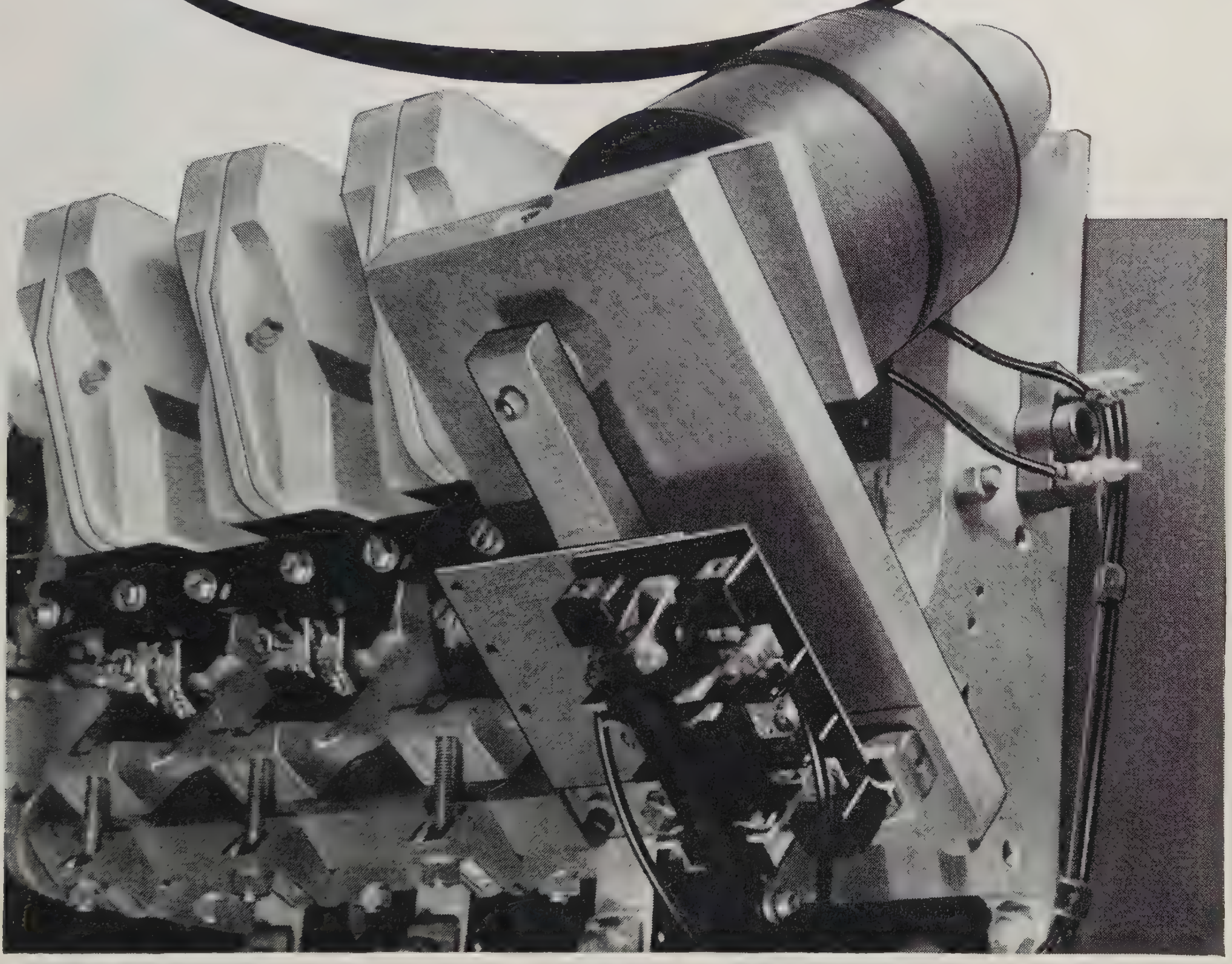
We also design and erect Open Hearths, Batch Annealing Plants — Single and Multi-stack, Continuous Annealing Furnaces — Horizontal and Vertical, Atmosphere Gas Generators, Rotary Hearth Furnaces complete with Automatic Charge and Discharge Machines, Continuous Pusher Reheating Furnaces and all types of Heat Treatment Furnaces.

P 7190



BILLET REHEATING FURNACE WITH TYPHOON BURNER

Control gear planned precisely



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AEI offers tailor-made control gear* for every industrial application, *and* provides a complete engineering advisory service.

**and motors too*

Write for further information to :

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Motor and Control Gear Division
RUGBY & MANCHESTER, ENGLAND

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ELECTROSTATIC PRECIPITATORS

Publication S7018 gives particulars of Sturtevant Electrostatic Precipitation and will be supplied on request.

Sturtevant CLEAN AIR

STURTEVANT ENGINEERING CO. LTD., SOUTHERN HOUSE, CANNON STREET, LONDON, E.C.4

AUSTRALIA: STURTEVANT ENGINEERING CO. (AUSTRALASIA) LTD., MILLER ROAD, VILLAWOOD, N.S.W.

STELVETITE—

plastic bonded to steel has put a new face on the

SADIA TWO-PLUS

Water Heater

The use of Stelvetite in the manufacture of the Sadia Two-Plus provides a perfect example of the economy it achieves. Aidas Electric Ltd. decided to open a satellite factory at Salisbury to make this popular heater. The factory was planned around the exclusive use of Stelvetite for casings, thus eliminating the need for a paint shop because Stelvetite has a finished surface.

As a result capital costs were cut by 17½% and production started three months earlier than would otherwise have been possible. This economy is additional to the cost and time saved in actual manufacture

The P.V.C. surface of Stelvetite is impervious to superficial knocks, chips and scratches, yet it is decorative, heat resistant, an insulation and its colour holds fast.

Stelvetite

Plastic bonded to Steel

* *Accepted by the Council of Industrial Design for "Design Index"*

All enquiries about the Sadia Two-Plus Water Heater should be addressed to Aidas Electric, Sadia Works, Rowdell Road, Northolt, Middlesex.

*STELVETITE—made in co-operation with BX Plastics Ltd. by

JOHN SUMMERS & SONS LTD

Write to us at Dept. JS · Shotton · Chester · for full information

Shell demonstration

The stability and anti-rusting properties of soluble cutting oils vitally affect the sustained performance of a machine tool.

Shell Research has painstakingly studied these qualities by the comparative evaluation of different emulsifying and coupling agents. This Shell-devised rig, the Shell Emulsion Stability Test, simulates under strict control, but more severely than usual industrial applications, the conditions in which soluble oils operate.

A gallon of the emulsion is circulated continuously for 48 hours through a copper feed-pipe and over a heated iron tube before percolating back to the sump through a layer of steel turnings. Water evaporation is made up at prescribed intervals and at the end of the test.

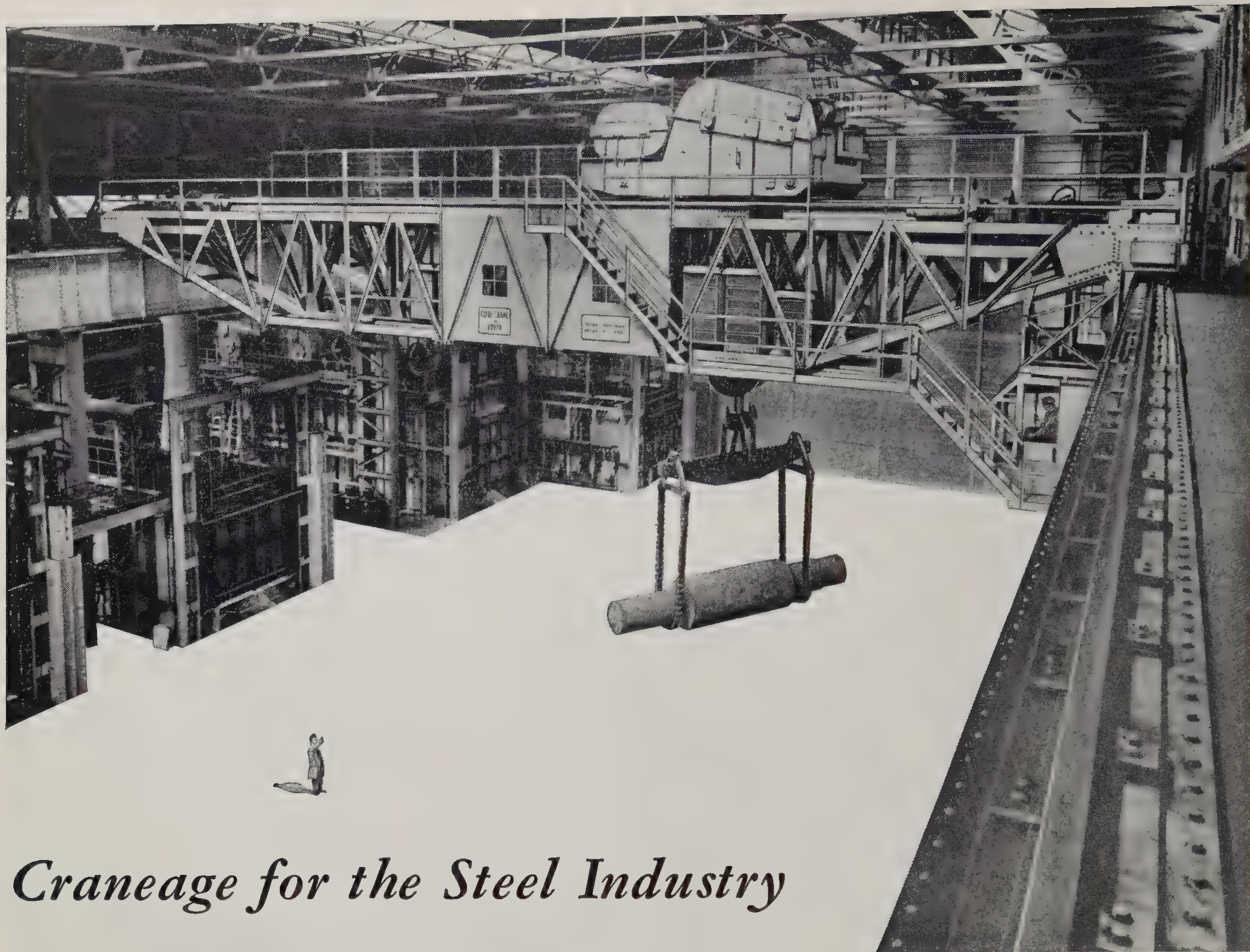
The appearance of the oil and the condition of the feed-pipe, iron tube and turnings reveal the extent of the corrosion.

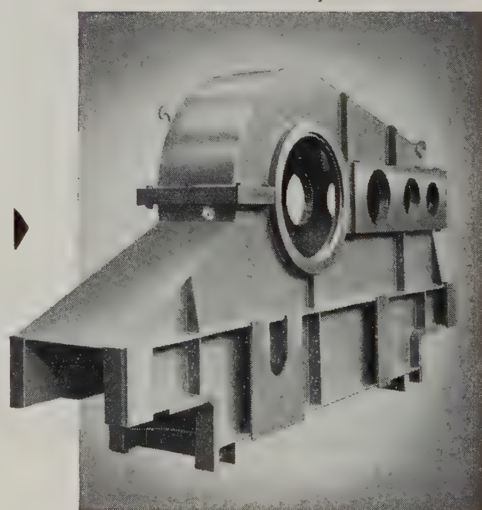
By comparing the percentage change of oil content in the slurry before and after the test, the stability of the emulsion can be expressed quantitatively.

Write for the booklet, Selecting Your Cutting Oils, to Lubricants Dept., Shell-Mex House, London, W.C.2.

SHELL

SHELL CUTTING OILS





Machinery Enthusiasts

There isn't much they don't know about that machine of theirs. But when it comes to industrial machinery, Wards are the people to consult. New or second hand, Wards offer a range of plant and equipment so wide that the task of the machinery buyer is considerably eased.

In the field of new machinery, Wards is a shop window for well-known makers. In the reconditioned field, they have an enviable reputation for skilled and knowledgeable workmanship which gives a new lease of serviceable and trustworthy life to second hand plant. The machinery user who deals with Wards seldom has to look further for his needs. The supplying of industrial machinery is just one activity of the Ward Group of Companies whose products and services cover almost every branch of industry.

Serving Industry Around the World **THOS. W. WARD LTD**

Head Office: ALBION WORKS, SHEFFIELD. *London Office:* BRETTENHAM HOUSE, STRAND, W.C.2.

GP.110

add together these **seven** major advantages

Greater Resistance to attack of molten iron and slag

Low after-contraction

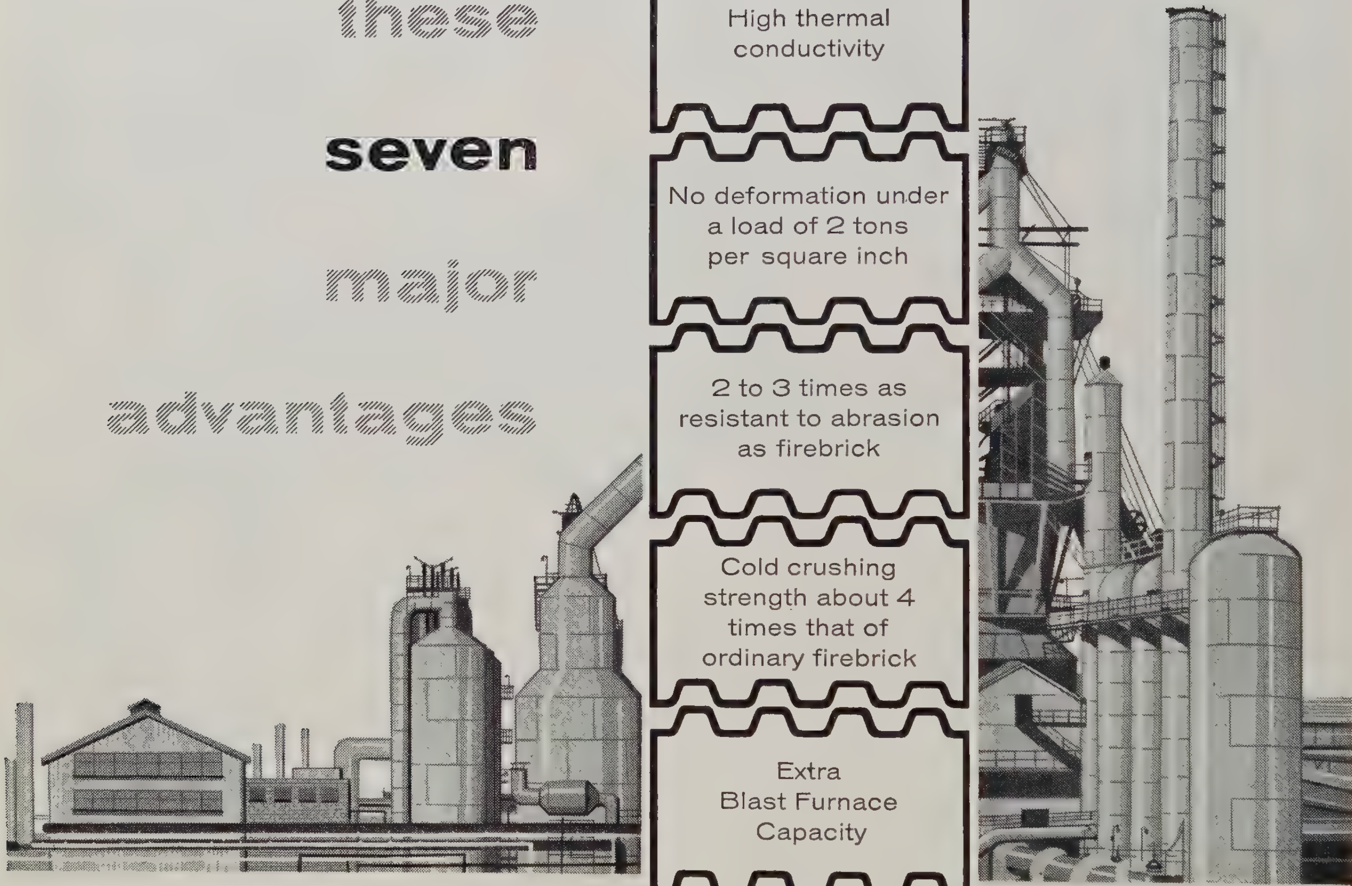
High thermal conductivity

No deformation under a load of 2 tons per square inch

2 to 3 times as resistant to abrasion as firebrick

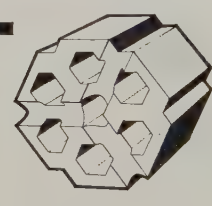
Cold crushing strength about 4 times that of ordinary firebrick

Extra Blast Furnace Capacity



and the result will be

CARBLOX



For filling hot blast stoves Carblox Limited now offer the TEMCO pattern chequer manufactured by our parent company, Thomas Marshall & Co. (Loxley) Ltd. This new chequer has an effective brick mass of 99%—higher than any other type of chequer. Details sent on request.

Write for catalogue to:-
CARBLOX LTD. STORRS BRIDGE WORKS
LOXLEY, Nr. SHEFFIELD. Tel: 343844/5/6

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One of the MARSHALL REFRACTORIES GROUP of Companies


FOR IRON ORE CRUSHING
IN SINTER PRODUCTION
Over 90 per cent of the tertiary crushing of wet and sticky ores in British steel-works is done by Pennsylvania Dixie Non-Clog Hammermills.
This, the largest hammer-mill ever produced in Britain, was built at the Erith Works of G E.C.
RELY ON THE EXPERIENCE OF
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For further information, write to: G.E.C. (Engineering) Limited Fraser & Chalmers Engineering Works Erith Kent
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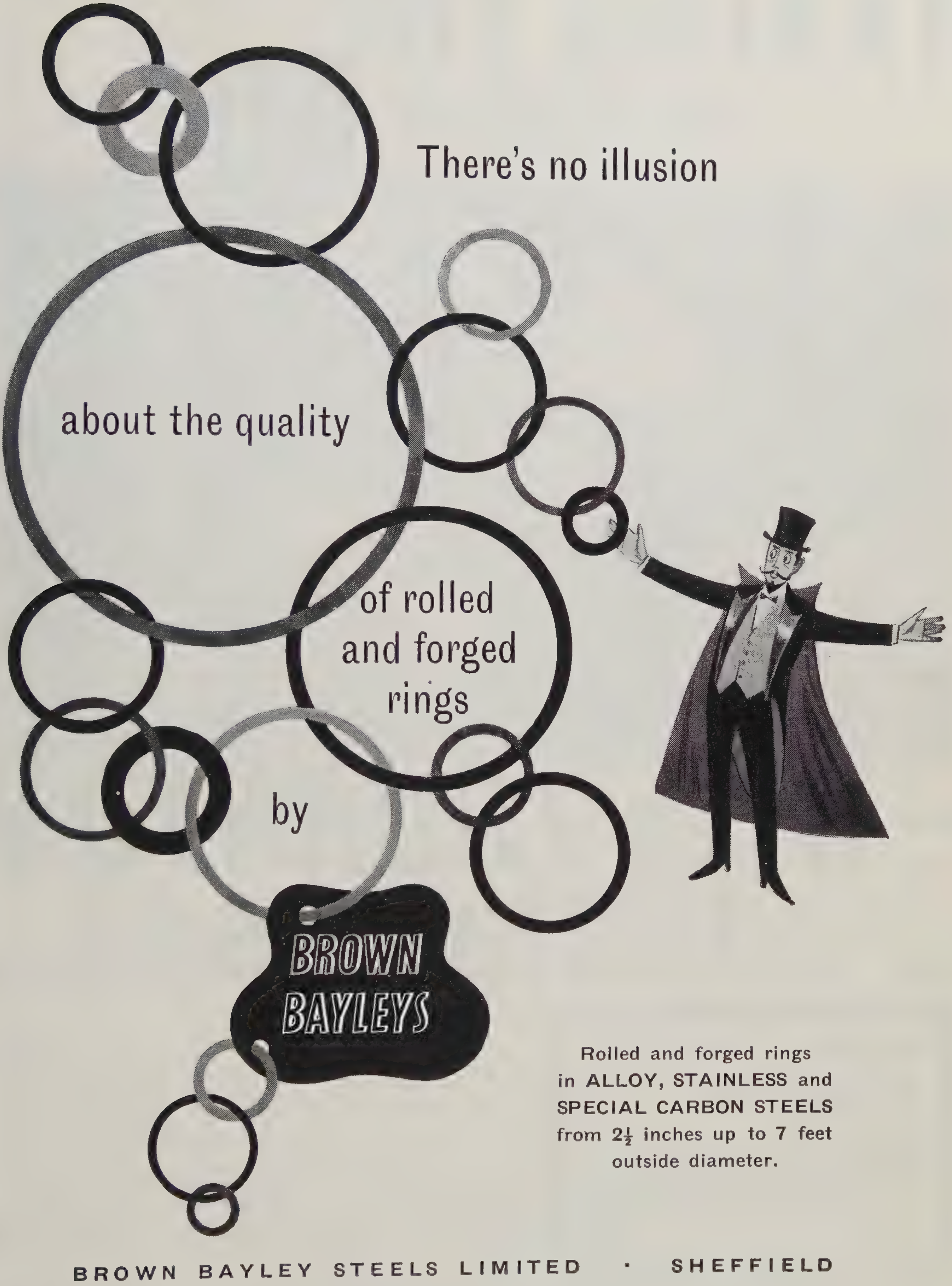
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about the quality
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by
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Rolled and forged rings
in ALLOY, STAINLESS and
SPECIAL CARBON STEELS
from 2½ inches up to 7 feet
outside diameter.
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SACK
SACK
SACK
2 High Reversing Slabbing Mill
Roll dimensions: 47" dia. x 118" barrel length.
Drive: 2 x 6000 H.P.
The second built for Yawata Iron and Steel Co., Japan, since 1957, by
MASCHINENFABRIK SACK
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FWS

1

2

3

4

5

6

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8

9

1. 15 ton Goliath crane 75 ft. rail centres: 60 ft. clearance—*courtesy: Tees Side Bridge & Engineering Works Ltd.*

4. Two 4 ton cupola chargers and 3 ton overhead crane equipped with magnets on one gantry—*courtesy: Head, Wrightson & Co. Ltd.*

7. Three 40 ton cranes—each 80 ft. span—*courtesy: Ferranti Ltd.*

2. Three 10 ton overhead cranes 93 ft. 6 in. span—*courtesy: Cammell Laird & Co. Ltd., Birkenhead*

5. 90 ton crane—57 ft. span—*courtesy: Fairfield Shipbuilding & Engineering Co. Ltd.*

8. Two cranes 35 tons and 15 tons, each 57 ft. 6 in. span—*courtesy: Davey Paxman & Co. Ltd.*

3. 30 ton, 50 ft. span overhead crane with 15 ton auxiliary lift—*courtesy: Hick, Hargreaves & Co. Ltd., Bolton*

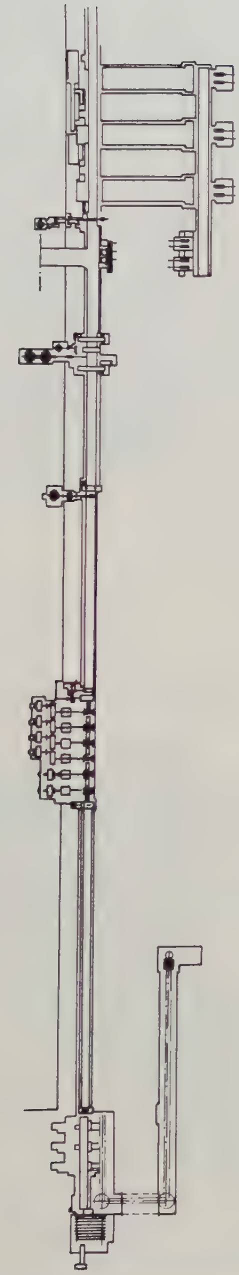
6. Cupola charger with tractor for mechanised foundry—*courtesy: B.T.C. (M.R.) Horwich Works*

9. Two cranes—each 5 tons—50 ft. span—*courtesy: T. J. Thompson & Son Ltd.,* Stockton-on-Tees

Overhead travelling cranes up to 100 tons; Cupola chargers; Transporters; Traversers and Winches.

S. H. HEYWOOD & CO LTD REDDISH STOCKPORT CHESHIRE

heywood cranes



Three-quarter continuous wide strip mill Rourkela

The DEMAG built wide strip mill supplied to the Rourkela Iron and Steel Works is capable of rolling slabs with the following maximum dimensions: length 6,000 mm., width 1,550 mm., and thickness 190 mm. The guaranteed production of the mill is 1,300 tons/8 hours. It was exceeded by 22 % even after only a short starting-up period. Maximum strip dimensions are 1,550 mm. wide and 1.6 to 10 mm thick. Maximum coil weight is 9 kg per mm. width with the maximum coil weighing 12 tons.

1. Two-high scale breaker

Via a roller table the heated slabs arrive at the scale breaker where they receive a reduction of about 10 % to remove the scale. Pressure water is used to spray off the scale.

2. Four-high reversing roughing stand

This stand reduces the stock generally in three passes and is used for edging.

3. Four-high non-reversing intermediate stand

Slabs rolled into strip are here given a single pass to reduce them to the required thickness for entry into the finishing mill. A light duty edging stand in front of the intermediate stand prevents the stock spreading.

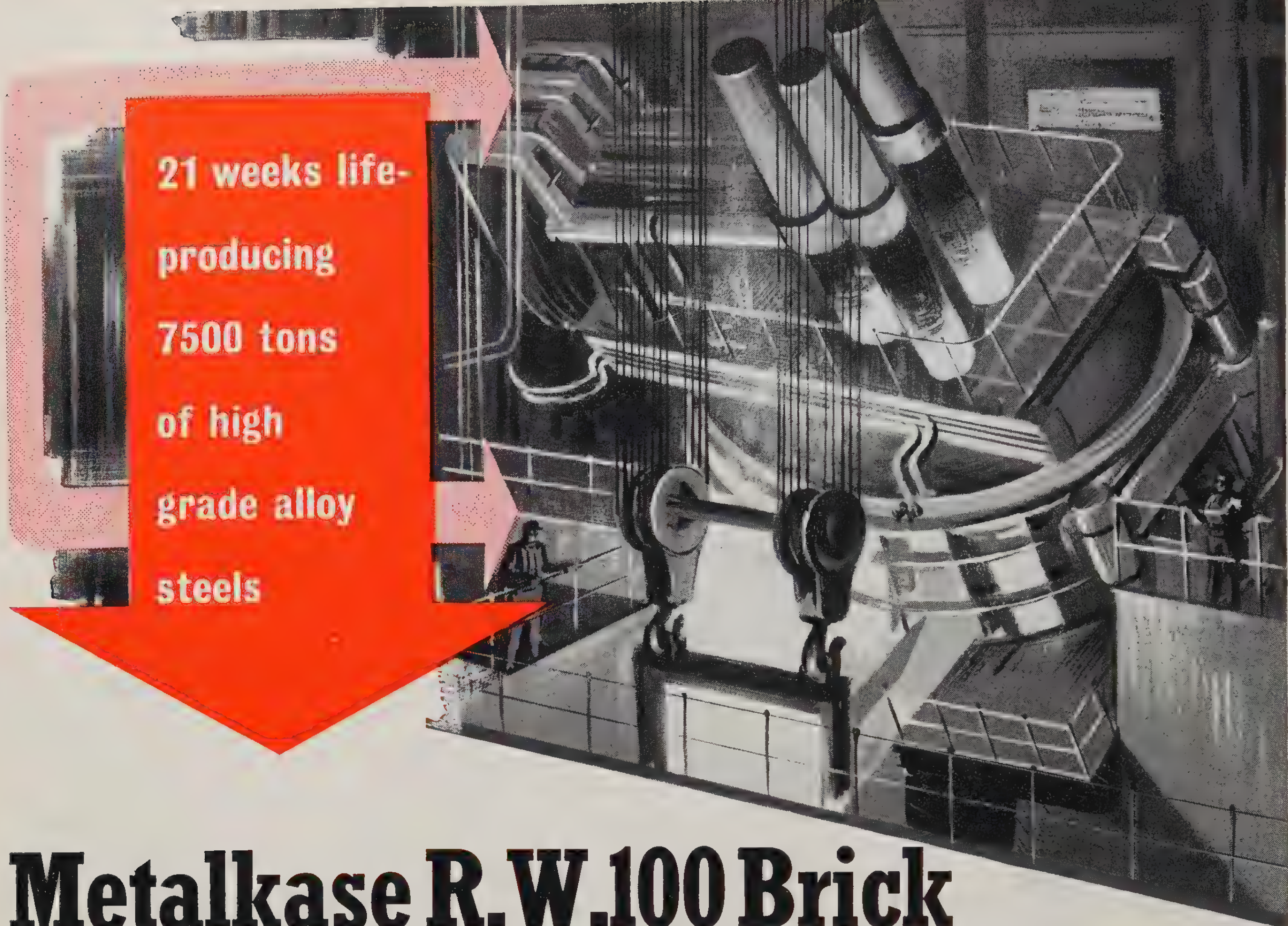
4. Six-stand four-high finishing mill

The strip is first cropped and, after passing the descaler, enters the six stands of the finishing mill for finish-rolling.

5. Down-coiler

Via a delivery roller table, including a 60 m. long strip cooling section, the strip is passed to two down-coilers. Here the strip is built up into coils and then deposited on a belt conveyor.

DEMAG AKTIENGESELLSCHAFT DUISBURG GERMANY



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(100% MAGNESITE · REINFORCED WELDED)

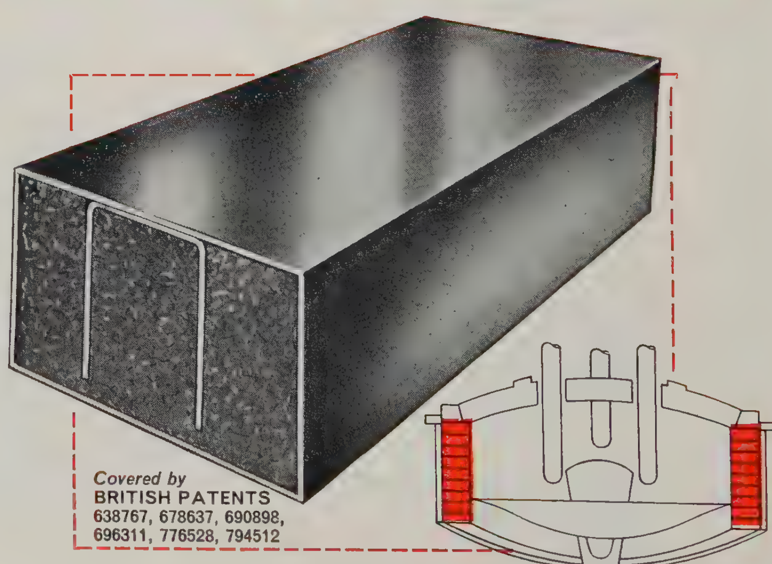
Unequalled for outstanding performance in Electric Arc Furnace Side Wall Construction

The outstanding refractory for electric arc furnace side wall construction, a magnesite product with no chrome addition and therefore particularly suitable for use when chrome pick-up in the metal must be avoided. Typical performance is 21 weeks life providing 7,500 tons of high grade alloy steels.

'METALKASE' BURNT BASIC BRICKS

FOR THE FIRST TIME the advantages of metalcasing can now be applied to burnt basic bricks, the case being firmly secured to the brick by welding in accordance with British Patents. If the preference is to have Basic Bricks BURNT these can still be metalcased with all the following attendant advantages—

- NO LOOSE SHEETS OR PLATES
- QUICK AND SPEEDY INSTALLATION
- SUPPORT TO BRICKWORK DUE TO REINFORCEMENT PROVIDED BY STEEL CASE



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JAMES B. AUSTIN, Ph.D.

JAMES BLISS AUSTIN, administrative vice-president, research and technology, of the United States Steel Corporation, was born in Washington, DC, on 16 July 1904. He attended Washington public schools and in 1925 graduated from Lehigh University with a degree in chemical engineering. He received the degree of doctor of philosophy in chemistry from Yale University in 1928.

Dr Austin has been associated with the research laboratory of the United States Steel Corporation since it was established in Kearny, NJ, late in 1928. For the first 12 years with the laboratory in Kearny, Dr Austin was engaged as a physical chemist, becoming supervisor of chemistry in 1941 and assistant director of the laboratory in 1944. Two years later he became director of research, succeeding the late Dr John Johnston under whom he had studied chemistry at Yale.

Before becoming director, he worked chiefly on the application of thermodynamics to processes for making or treating steel. He was also engaged in the measurement of properties of metals and refractories, especially at elevated temperatures. He remained director of research until July 1954, when he was appointed assistant vice-president, research and technology.

When the Kearny laboratory was moved to US Steel's research centre in Monroeville, Pa, in 1956, Dr Austin moved his office to Pittsburgh. He became vice-president, fundamental research, in July 1956 and vice-president, research and technology, in May 1957. In February of the following year he was appointed to his present post.

Dr Austin is a fellow of the American Ceramic Society and the New York Academy of Sciences. He is a member of the American Chemical Society, the American Society for Metals, the American Institute of Mining, Metallurgical and Petroleum Engineers, the American Iron and Steel Institute, and the British Ceramic Society. He is past chairman of the New York section of the American Society for Metals and has served on the publication committee of the national society. He delivered the Edward de Mille Campbell Memorial Lecture before the ASM in 1946 on the nature and composition of carbides which occur in steel. He was a trustee of the ASM in 1951–52, national vice-president in 1953, and national president in 1954.

Dr Austin served as a member of the Chemical Warfare Committee of the Research and Development Board of the Department of Defense from 1949 to 1953, and was chairman in its final year of being.

A past chairman of the Refractories Division of the American Ceramic Society, he was a trustee of the Society from 1943 to 1946. He gave the Society's Orton Memorial Lecture in April 1952.

Dr Austin has been a member of The Iron and Steel Institute since 1947. He was elected an Honorary Vice-President in 1961.

James B. Austin, Ph.D.
Honorary Vice-President

Paint performance on grit blasted ships' hulls

J. C. Rowlands

SYNOPSIS

A number of factors concerning the grit blasting of ships' hulls and the effect on paint performance have been examined. The paint film thickness required to give adequate protection to the steel was dependent on the surface roughness of the blasted surface. Far superior protection was obtained by using a suitable pretreatment primer and this should be applied as soon as possible after grit blasting. Using compressed-air blasting machines the surface roughness was found to be roughly proportional to the average grit size. 1997

INTRODUCTION

IN RECENT YEARS there has been an increasing interest in mechanical blasting techniques for cleaning ships' hulls before painting. Such methods have been favoured for many years in the USA, and there is little doubt that their use of wet sandblasting enabled them to apply protective compositions giving superior performance to those used in this country. In most of Europe sand is not used for grit blasting ships' hulls because of the possible risk of silicosis to operators.

The object in using blasting processes for cleaning and descaling is to obtain an improved surface finish on ships' plating for painting. Subsequently applied paint systems should give improved performance, and in the case of outer bottom plating this should lead to an increase in the period between dry dockings. By obtaining a smooth finish on the outer bottom, friction losses are reduced thus increasing the ship's speed and improving fuel consumption. Proper surface preparation, as obtained by grit blasting followed by a good outer-bottom protective system correctly applied, can contribute considerably to these conditions.[1]

The majority of portable blasting machines suitable for cleaning ships' hulls work on the compressed air principle in which the abrasive is projected from a nozzle at high velocity in an air stream. Working on this principle there are two types of processes commercially available. In the closed system the abrasive, usually steel shot or grit, when spent is collected under vacuum for filtration and reuse, whereas in the open system a cheap abrasive is used which, when spent, is of no further use and requires disposal. The main advantage of the closed system over the open system is that it is clean and safe to operate but it has disadvantages in that much more machinery is required and the cleaning rate is slower. The choice of whether to use the closed or open system is mainly a question of economics and facilities available in any particular shipyard.

The commercial introduction of these techniques has given rise to many questions such as the effect of surface roughness on the life of the paint system, and the type of abrasive to use. These investigations were undertaken to answer this question.

EFFECT OF SURFACE ROUGHNESS ON PAINT PERFORMANCE

There have been opinions expressed regarding the optimum surface roughness for painting, and the thickness of the paint film required to cover the peaks of a rough surface. The object of this investigation was to elucidate these factors.

Specimen test panels were grit blasted with a closed system machine using various grades of chilled iron grit (commonly termed steel grit in the trade) corresponding to BS 410 mesh sizes 12, 14, 16, 18, 22, 30, and 52. The maximum profile heights measured as the vertical distance between a peak and a valley were determined for surfaces blasted with each grade of grit, by sectioning and microscopic examination. From these surface roughness measurements it was apparent that the maximum profile height was proportional to the grit diameter as shown in Fig.1.

Further $12\text{in} \times 12\text{in} \times \frac{1}{4}\text{in}$ test panels, grit blasted as above, were prepared with and without a pretreatment primer* and three, five, or seven coats of Anticorrosive 655[2] followed by one coat of Admiralty Antifouling paint 161P. The dry film weights and the calculated average film thicknesses of the various paint coats were as follows:

	oz/yd²	mils
Pretreatment primers	0·3–0·8	<0·5
Anticorrosive 655	1·7–2·5/coat	1·2–1·8/coat
Antifouling 161P	3·4–4·0	1·8–2·2

On the rougher surfaces it was generally found that more paint was used for the first anticorrosive coat, i.e. approaching 2·5 oz/yd² whereas with the smoother surfaces only 1·7 oz/yd² would be used. After painting, the specimen panels were immersed from one of the Admiralty exposure rafts in Langston Harbour for two years.

Visual assessment of these painted panels after the exposure period showed that the number of coats of Anticorrosive 655 and the presence of a pretreatment

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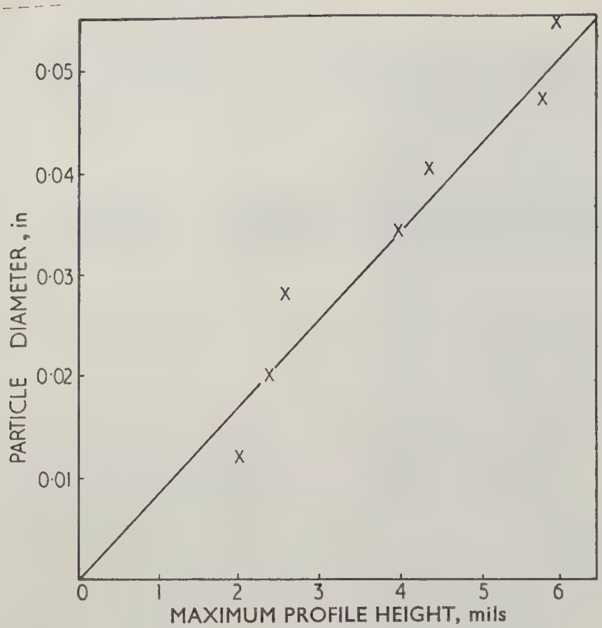
* Pretreatment primer is to Ministry of Supply Specification CS2626D and consists basically of zinc chromate, phosphoric acid, and butyric resin.



1 *Effect of particle size on surface roughness*

primer had considerable effect on the paint performance. Specimens treated with the pretreatment primer exhibited no paint breakdown* even when there were only three coats of anticorrosive present. In the absence of a pretreatment primer the seven coat anticorrosive system was perfect, but with the five coat anticorrosive system there was up to 5% of the paint broken down, and with the three coat anticorrosive system there was considerable paint breakdown the extent of which was dependent on the surface roughness as shown in Table I.

EFFECT OF WEATHERING AFTER GRIT BLASTING ON THE PAINT PERFORMANCE

Under shipyard conditions it is rarely possible for ships' plate to be painted immediately after grit blasting, which gives rise to the question of the effect of weathering between blasting and painting.

A further set of specimen panels were prepared by grit blasting with various grades of chilled iron grit in order to obtain various surface roughnesses. For controls, similar specimen panels were prepared by acid pickling followed by weathering for three months and wire brushing before use. Panels with each surface preparation were painted after weathering for 0, 8, 24, and 36 h under dry marine aerial conditions. The protective system used was three coats of Anticorrosive 655 followed by one coat of Antifouling 161P. After the panels were painted they were exposed under marine full immersion conditions for two years.

* Paint breakdown is defined as the percentage area of the panel over which the paint has failed by blistering, flaking to bare metal, and rusting.

TABLE I Effect of surface roughness on paint performance: three coats Anticorrosive 655

Abrasive chilled iron grit size (BS 410 mesh)	12	14	16	18	22	30	52
Maximum profile height (mils)	6·0	5·8	4·4	4·0	2·6	2·4	2·0
Paint breakdown, %	80	80	75	75	15	15	15

TABLE II Effect of weathering time on paint performance

Surface preparation (grit size, BS 410 mesh)		12	14	16	18	22	30	52	Wire brushed
Maximum profile height (mils)		6·0	5·8	4·4	4·0	2·6	2·4	2·0	...
		Paint breakdown, %							
Weathering, h	0	75	75	80	40	30	20	25	10
	8	90	90	80	75	20	25	20	75
	24	80	75	90	75	60	35	50	75
	36	90	75	80	80	40	50	40	75

The time interval between grit blasting the steel plate and the application of the first coat of paint was found to affect the paint performance as shown in Table II.

The outstanding performance of the wire brushed panel was attributed to the superior surface condition that is obtainable under laboratory testing conditions. When the wire brushed panels were weathered to a condition that was comparable to the quality of the finish generally obtained on a ship's hull, the paint performance was inferior to that obtained with the finer grit blasted finishes. This illustrates the benefit of applying paint systems to grit blasted surfaces.

PROPERTIES OF OPEN BLASTING ABRASIVES

It is uneconomic to collect the spent grit from the floor of the dry dock for reuse, and hence the abrasive should be cheap. Since the use of sand is prohibited for any open grit blasting process that is practical for cleaning ships' hulls, the choice of abrasive rests with either silica-free sands such as olivine or the slags from metal refining processes which are waste products. Some of the metal refining slags which might be considered for open grit blasting are listed in Table III, together with their chemical compositions and specific gravities.

Commercial samples of each of these products were obtained. These samples were found to vary considerably in particle size as shown in Table IV. In order to obtain an average grit size, the average coarseness was calculated:

$$\text{Average coarseness} = \frac{1}{\text{average grain fineness}}$$

$$= \frac{\text{total sum of \% retained on sieves}}{\text{\% retained on each sieve} \times \text{mesh size of next largest sieve}}$$

Grit blasting trials were carried out with these samples using a $\frac{3}{8}$in dia. nozzle held 18in from the plate, the pressure of the compressed air supply being 80 lb/in^2. Areas of about 15 ft^2 on a rusty mild steel plate were blasted to assess the merits of each abrasive and the hazards to the operator. The operator was of the opinion that there was little to choose between the copper refining and blast-furnace slags, but the lead refining grit broke up on impact with the steel plate,

TABLE III Percentage compositions of metal refining slags

Refining process	SiO_2 (as silicate), %	CaO+ MgO, %	FeO, %	Remainder, %	Specific gravity
Copper slag	32–45	25–33	24–35	...	3·63
Iron blast-furnace slag	33–47	31–48	1–2	Al_2O_3 5–25, Mn 1–3	2·95
Lead slag	28–37	16–21	30–45	Al_2O_3+ZnO up to 10%	3·5

TABLE IV Particle sizes of abrasive samples

Abrasive		Mesh size (IMM) 8	10	12	16	20	30	40	50	60	80	100	Average coarseness
		% retained on sieve											
Copper refining slags	*A*	14	16	54	14	1	1						0·104
	B	4	10	44	16	18	6	2					0·083
	C			2	18	60	16	3	1				0·062
	D	(Remaining 25% less than 100 mesh)						21	21	21	6	6	0·022
Blast-furnace slags	*A*	7	8	45	20	17	2	1					0·088
	B		10	32	26	24	4	2	2				0·076
Lead refining slag			4	38	16	26	7	6	1	2			0·068

producing a high percentage of dust, and hence this slag was not considered suitable for shipyard use. With the coarse grades of copper refining slag it was observed that grit particles became embedded in the steel plate.

In order to measure the surface roughness obtained with each abrasive a number of 15in × 10in × $\frac{3}{16}$in panels were grit blasted. These panels before blasting were in the smooth 'as-rolled' condition. In this instance the surface roughnesses were measured using a 'Talysurf'. The values for the maximum profile height were found to agree very closely with those obtained by sectioning and microscopic measurement, and by the method in which the blasted surface is viewed through a microscope focused first on the peaks and then on the valleys.[3] The maximum profile heights obtained on the specimen panels using each abrasive are shown in Table V.

The grain coarseness was found to be related to the surface roughness of the cleaned steel, as shown in Fig.2. On this graph the relationship between surface roughness and grain coarseness for the copper refining slag is shown by a continuous line, and that predicted for the blast-furnace slags by the dotted line. The grain coarseness was used as a measure of the particle size, and if divided by a factor of 2·5 an approximate value for the average grain size in inches is obtained.

PAINT PERFORMANCE ON MILD STEEL SURFACES GRIT BLASTED WITH VARIOUS ABRASIVES

After grit blasting mild steel, particles of embedded abrasive invariably adhere to the steel. When investigating the properties of mild steel weld slags and their effect on paint performance,[4] it became apparent that slags of the iron silicate type adhering to mild steel could simulate galvanic corrosion and adversely affect the paint performance.

Several slags of the iron silicate type are commercially available for grit blasting, of which the most extensively used is the copper refining slag.

The electrode potentials of mild steel, mill scale, and the copper refining slag in sea water at 20°C were measured with reference to a saturated calomel half cell with the following results:

Mild steel	−0·65 V
Copper refining slag	−0·3 V
Mill scale	−0·2 V

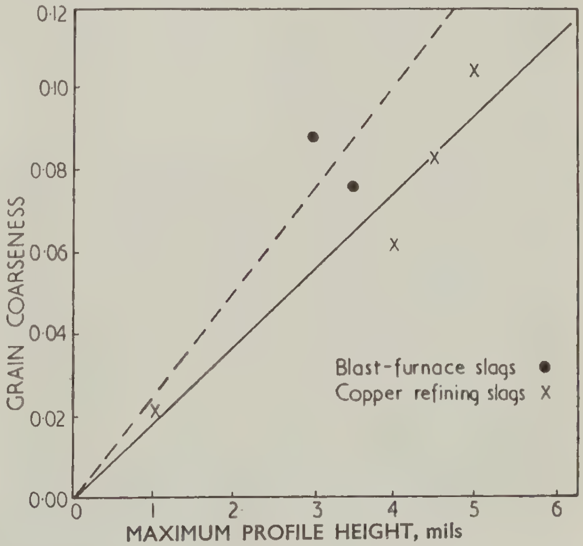
In order to investigate the effect of abrasive particles adhering to mild steel under a paint system, specimen 6in × 10in × $\frac{3}{16}$in panels were grit blasted. Two different degrees of surface roughness on panels prepared by grit blasting using the copper refining slag were obtained by holding the blasting nozzle 48in and 18in from the panels. Four specimens with each surface roughness were prepared. To act as controls four similar panels were grit blasted with steel grit using a closed blasting process. The surface roughnesses of the specimen panels were measured by the microscopic vertical method described previously, and were as follows:

Abrasive	*Maximum profile height, mils*
Copper refining slag	
Fine finish	2·5
Rough finish	4·5
Steel grit	3·0

Duplicate specimen panels with each of the above surface finishes were painted with each of the following protective systems: (i) three coats Anticorrosive 655+ one coat of Antifouling 161P; (ii) one coat pretreatment primer+three coats of Anticorrosive 655+one coat of Antifouling 161P. The average dry film thicknesses were: pretreatment primer <0·5 mils; Anticorrosive 655, 5·0–5·7 mils; and Antifouling 161P, 1·4–1·9 mils.

TABLE V Maximum profile height on steel plate after blasting

Abrasive		Grain coarseness (from Table IV)	Maximum profile height, mils
Copper refining slags	*A*	0·104	5·0
	B	0·083	4·5
	C	0·062	4·0
	D	0·022	1·0
Blast-furnace slags	*A*	0·088	3·0
	B	0·076	3·5
Lead refining slag		0·068	4·0



2 *Relationship between grit coarseness and surface roughness*

TABLE VI Paint performance on steel grit blasted with chilled iron or iron silicate

Abrasive	Maximum profile roughness height, mils	Pre-treatment primer	Paint breakdown, %
Copper refining slag	2·5	Nil	30
Copper refining slag	4·5	Nil	20
Chilled iron grit	3·0	Nil	5
Copper refining slag	2·5	1 coat	5
Copper refining slag	4·5	1 coat	5
Chilled iron grit	3·0	1 coat	1

The painted panels were immersed for one year from a raft in Langston Harbour. On completion of the exposure period the panels were cleaned and examined. It was obvious that there was less paint breakdown on the steel-grit blasted panels than on those blasted with the iron silicate slag. Using the pretreatment primer a far superior paint performance was obtained, but the same difference between the two abrasives was apparent, as shown in Table VI.

It will thus be observed that the surface roughness alone had very little effect on the paint performance.

Having obtained such an obvious difference in paint performance between these two abrasives a second trial is being conducted to compare the paint performance on panels prepared using blasting grits of chilled iron, blast-furnace slag, lead refining slag, and copper refining slag. These panels painted with a five coat anticorrosive system have been exposed under marine full immersion conditions for ten months and to date there is no paint breakdown.

DISCUSSION

From the surface roughness measurements on steel plate blasted with graded chilled iron grits it was evident that the maximum profile height was proportional to the grit size. When the abrasive was of a variable particle size it was apparent that the maximum profile height was about proportional to the average particle size. As the velocity of abrasive particles is only about 15% of the air velocity[5] it would not be surprising if the smaller particles were moving with higher velocity. Since the impact energy is proportional to the particle mass and the square of the velocity ($KE=\frac{1}{2}\ mv^2$) there will be an optimum particle size in any aggregate which will cause the greatest surface roughening.

There was evidence that abrasives of high specific gravity caused greater surface roughening but no mathematical relationship was established. It might also be expected that the shape of the grit can affect the maximum profile height since grit with sharp corners would penetrate further into the steel plate than grit with rounded corners. A surface roughness factor of 3:4 has been illustrated between steel shot and angular steel grit of the same particle size.[3]

The rate of cleaning was not fully investigated but it was apparent that the finer grits gave faster cleaning, and more abrasive was consumed. Hence there is an optimum particle size for maximum economy which accounts for labour, machinery, and abrasive costs per unit area cleaned. Such a factor would have to be evaluated for any particular type of grit by full scale trials. There is, however, an overriding factor that the abrasive must be of sufficient size to provide adequate cleaning such as the removal of old paint, marine fouling, mill scale, and weld slag.

The paint performance on mild steel after grit blasting with an iron silicate abrasive has been shown to be inferior to that using chilled iron grit as the abrasive. It is believed that the reason for this phenomenon is the embedding of abrasive particles in the steel plate being cleaned. Such iron silicate particles are invariably cathodic to mild steel since they contain the iron oxides Fe_3O_4 and FeO which are known to be conducting and semi-conducting respectively, and are cathodic to steel. In neutral electrolytes an electrochemical reaction gives rise to a hydroxyl ion concentration at the cathode and causes paint blistering.[6] Consequently any cathodic particles embedded in grit blasted steel plate could initiate paint breakdown. The use of a pretreatment primer was exceptionally efficient in reducing paint breakdown due to this cause. The fact that no paint breakdown was observed on such test panels with a thick anticorrosive system after ten months exposure indicates that the entrapment of slag particles in the grit blasted plate is not a serious problem.

The results obtained for the paint performance on surfaces of varying roughness were conclusive in themselves and were in agreement with the general findings of similar work in which red lead paints were used.[3]

CONCLUSIONS

The results indicate that provided an adequate thickness of paint is applied the surface roughness is a minor factor in determining paint performance. It is evident that on grit blasted surfaces the application of one coat of pretreatment primer is equivalent to at least two coats of Anticorrosive 655 in its effect on preventing paint breakdown. When using thick paint systems, i.e. one coat pretreatment primer+five coats Anticorrosive 655 the effect of surface roughness appears negligible. If for economic purposes the use of a thinner paint system is contemplated the surface roughness factor should be taken into account and an appropriate grade of grit used for blasting.

The excellent performance of the wire brushed panels which were painted without any intermediate weathering was attributed to the superior surface condition obtainable in the laboratory as opposed to the finish obtained on a ship's hull. When similar panels were slightly weathered to a condition comparable to the finish generally obtained on a ship's hull the paint performance was inferior to that on the smooth grit blasted surfaces. The effect of weathering grit blasted surfaces was to reduce the effective paint life and consequently the practice of allowing a grit blasted surface to show a brown tinge before applying the pretreatment primer is not recommended.

The ideal properties of an abrasive for compressed air blasting of ship's plate are that the particle size should be as small as possible for efficient blasting and the grit should have a high specific gravity. Preferably the abrasive should be either electrically non-conducting or, if conducting, its electrode potential should be similar to that of mild steel.

The outstanding recommendation obtainable from these investigations is that a suitable pretreatment

primer should be applied to the grit blasted steel before the main anticorrosive system for improved paint performance.

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Annealing of whiteheart malleable iron in iron ores

J. C. Wright, Ph.D., A.I.M., W. J. Elder, Dip.Tech., L.I.M., and J. C. Billington, Ph.D., D.I.C.

SYNOPSIS

The paper reviews present practice for annealing whiteheart malleable castings in iron ores, and discusses factors over which the annealer should exercise strict control. Methods of improving annealing ore quality are considered, but practical tests show them to be of little value, and attention is concentrated on magnetic cleaning of the returned-ore part of the annealing ore mixtures. This cleaning process removes a considerable quantity of harmful slag-forming impurities when these are present as discrete kibble-sized particles without impairing the decarburizing qualities of the cleaned ore mixtures. Annealing trials are reported using two commercial hematite ores mixed with magnetically cleaned and normal returned ores. It is shown that sticking problems are more serious when the gangue particles are present as discrete particles, and therefore magnetic cleaning of the returned ore is beneficial in such a case. This cleaning had no retarding influence on the rate of decarburization achieved in the trials, and in fact the value of circulating partially spent ore is questioned. 2001

The annealing of whiteheart malleable iron, by packing white iron castings in iron ores followed by heating, is more widespread, both in tonnage treated[1] and in the number of foundries operating the process, than the controlled atmosphere gaseous process using electric furnaces. Thus, annealing by iron ore is still important and this account reviews present knowledge on the mechanism and the practical application of the process, and describes work investigating certain of its aspects. The aim for higher production by the iron ore process has been attended by increased difficulty in its operation. Before considering these difficulties in detail, the basic factors controlling the process will be examined and then related to the present difficulties.

THEORY OF THE WHITEHEART MALLEABLE ANNEALING PROCESS

Annealing by the ore packing or Réaumur process involves a three-stage cycle. These stages are: (i) packing the castings in a carefully sized iron ore mixture in luted annealing cans and heating slowly to a temperature between 950° and 1 050°C; (ii) holding at this temperature for sufficient hours, depending on the section and composition of the castings, to eliminate free cementite from the castings by solution in the austenite decarburization, and precipitation of the excess carbon as graphite nodules; and (iii) cooling very slowly to and through the critical temperature range to avoid precipitation of grain-boundary hypereutectoid cementite, followed by fairly rapid cooling to room temperature. The final structure of thin-section castings consists of a ferrite matrix with dispersed graphite nodules. Thin-section castings show an outer zone of ferrite and a central zone of pearlite matrix and graphite nodules. These structural changes have been dealt with at length by Hall[2] and Palmer.[3] However, it is necessary to show how the desired annealing conditions affect the ore mixtures used in the process.

When the annealing temperature is examined from the point of view of the ore certain limitations must be considered. The oxidizing potential of the ore will increase with increasing temperature and although it is desirable that this potential should be high to achieve efficient decarburization of the castings it is also necessary to limit the oxygen available so as to avoid scaling the castings and depleting the ore of its oxygen too quickly. Most annealing ores contain gangue materials and if the annealing temperature is too high there is a danger of fluxing between the gangue and ferrous oxide which forms in the ore mixture during the annealing process by the following reactions:

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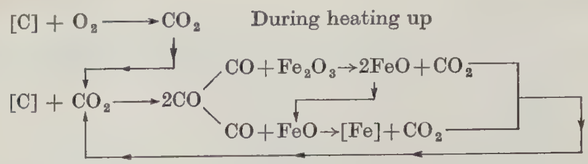
Dr Wright and Dr Billington are with the College of Advanced Technology, Birmingham, and Mr Elder is with Brush Electrical Engineering Co., Loughborough.



The gas atmosphere in the annealing cans is a carbon dioxide/carbon monoxide mixture whose composition is largely controlled by the annealing temperature, which in turn controls the rate of diffusion of carbon through the austenite in the castings and the rate of reaction with the ore particles. At the start of the annealing process when the carbon concentration at the surface of the casting is a maximum so also is the oxidizing potential of the ore, since the diffusion of oxygen through each particle is either unnecessary or the diffusion path is very short. Therefore the maximum rate of decarburization is achieved at the start of the process and is controlled by the rates of reaction of carbon and oxygen in the annealing cans and not by the diffusion rates of these elements through their respective media, as is the case in the later stages of the process. The active ferrous oxide produced during the annealing process is available to form low melting point mixtures with the gangue constituents of the ore mixture; if the annealing temperature is too high, a liquid component is formed between the ore and the castings.

Thus, it can be seen that the rate of oxygen supplied by the ore must not be so high as to cause rapid breakdown of the ore to fines, nor so slow as to restrict oxidation of the carbon at the casting surface. These requirements necessitate a compromise in annealing temperatures depending on the type of ore used.

PRACTICE OF ANNEALING IN ORE MIXTURES

In recent years difficulties in operating the ore-annealing process have increased. The main reason for this has been the gradual increase in annealing temperature in an effort to decrease annealing time and achieve higher production rates. Twenty years ago an annealing temperature of 950°C was regarded as an upper limit but at present temperatures as high as 1050°C are regarded as not abnormal and occasionally higher temperatures may be reached, although this is usually unintentional.

For reasons of economy, efficiency, and the application of the Clean Air Act, oil-fired furnaces are replacing the older type coal-fired furnaces. These oil furnaces are capable of more intense heating to higher temperatures. In addition, the most commonly used fuel oils introduce up to 3·2%S into the combustion zone. As explained in the previous section, higher temperatures accelerate the decarburization process, but more troubles arise from the subsidiary effects such as the collapse and fluxing of the ore. The latter effect leads to adhesion of the ore to the castings and an increased tendency to reduce the ore to metal. The introduction of sulphur into the annealing furnace atmosphere combined with high annealing temperature has undoubtedly increased the incidence of the heavy scaling defect known as ‘peeling’. Peeling defects have been known to occur owing to sulphur in the annealing ore, irrespective of furnace atmosphere, but the recent increase in peeling defects can very largely be ascribed to sulphur from fuel oil.

Until about 1957 a very large proportion of the ore used for whiteheart annealing in the UK was Cumberland hematite. These deposits have shown deterioration in recent years. The ore veins are narrower than formerly and the proportion of stone from the sidewalls and footwalls which is included in the ore as-mined has increased. The inclusion of increased amounts of gangue material reduces the refractoriness of the Cumberland ore in the annealing process.

The whiteheart malleable ironfounder wishes to take advantage of the increased production rates obtained with higher annealing temperatures, but there is a limit to the temperatures which even the highest grade ore will withstand. In fact some virtually pure hematite ores have been uneconomical because they collapsed to fines after one heat, and left very little suitable material for recycling with new ore in subsequent annealing cycles. Obviously a compromise must be sought between the preparation of a suitable ore at an increased cost to the annealer and the control of annealing conditions to give higher production rates.

ANNEALING ORE QUALITY

The quality of ore for the whiteheart malleable iron annealing process is not a simple thing to define. Ideally the ore should be rich in available oxygen from a high ferric oxide content and the oxygen should be released at a suitable rate. The ore should not break down to fines easily during the annealing process or it will be lost during the screening of the partially spent ore before re-use. The ore mixture should be sufficiently refractory to resist spalling and fluxing.

Fluxing depends to a great extent on the amount and type of gangue present. Mild cases of fluxing are revealed by isolated particles of the ore sticking to the surface of the casting. In these cases it is very likely that the particles will be impurities such as lime, arising from the calcination of limestone in the ore, or particles of iron oxide containing impurities. The worst cases of fluxing involve sufficient gangue to cause many particles of iron ore to cement themselves on to the castings, and the whole contents of the annealing can, castings and ore, are firmly stuck together in one mass. Serious cases of fluxing defects are exorbitantly expensive in recovering the castings. The ore and impurity particles may be removed by barrelling or similar cleaning processes, but the fluxing action frequently pits the casting deeply and the last traces of the slag may be very difficult to remove. This latter point is illustrated when attempts are made to galvanize castings which suffered only minor fluxing damage. The cleaning process may apparently have removed all traces of the defect but many of the defects will not be wetted in the galvanizing process and show up clearly as bare spots.

CONTROL OF THE ANNEALING PROCESS

Fluxing defects are frequently aggravated by insufficient control over the annealing conditions. Palmer[4] has illustrated the temperature distribution possible in coal-fired or pulverized fuel-fired annealing furnaces, and fluxing conditions will vary considerably within such furnaces. Gas- and oil-fired furnaces are better, but nevertheless the temperature distribution within each oven should be investigated and control thermo-

TABLE I Analyses of sponge iron close to casting surface

Total iron	71·7%
(Iron calculated as FeO)	92·4%
Silica	16·76%
Lime	2·30%
Magnesia	0·81%
Alumina	1·80%
Sulphur	0·039%

couples sited to give a reliable indication of temperature conditions within the furnace.

If fluxing constituents are present in potentially dangerous amounts, castings can still be annealed free from defects if suitable precautions are taken. Rigid maximum temperature control is essential and periods as short as 1 h with the temperature only a few degrees above the specified limit are dangerous. In the authors' experience, fluxing defects are more common from furnaces whose temperature control is erratic than from furnaces running at relatively high but consistent annealing temperatures.

Fluxing defects are aggravated by markedly reducing conditions occurring at the surface of the castings such as may arise from a slow rate of oxygen release from the ore. Reducing conditions can become sufficiently extreme for ore to be completely reduced in the solid state to sponge iron and to weld on to the casting. Such particles are impossible to remove from a casting without grinding.

As an illustration of the effect of such reducing conditions the analysis in Table I resulted from the examination of ore close to castings which showed very firm adhesion of kibbles, consisting mainly of sponge iron, to their surface.

It is evident from this analysis that free iron must be present in the spent ore, because even if the iron was present as ferrous oxide there would be insufficient allowance in the analysis to accommodate a minimum of 21·7% of impurities without considerably exceeding a total of 100%. X-ray diffraction analysis confirmed the presence of elemental iron and ferrous oxide but no ferric oxide was observed. It could then be shown that the ore contained at least 4% of free iron and no more than 29% of ferrous oxide. Further evidence of the presence of iron was given by the malleability of the affected kibbles which are usually very brittle. In this case they could be hammered flat without fracture and then presented a matt but metallic lustre. The castings, averaging 1in in section, were not sufficiently decarburized in spite of the fact that they had been treated for not less than five days at 1020°C in an oil-fired furnace. The castings which showed the worst ore reduction and adherence were taken from cans close to the direct flame from the oil burners. The temperature in these particular cans may well have exceeded 1020°C. Excessively reducing conditions can easily arise from using ore mixtures with too little available oxygen and an ore mixture strength which is too weak is undesirable. Since it is virtually impossible to exclude the furnace combustion atmosphere from entering the annealing cans during the annealing process, any tendency towards reducing conditions in combustion of the fuel will influence the atmosphere within the cans towards the reducing conditions. On the other hand, a fast release of oxygen from the ore promotes strongly oxidizing conditions within the can. These give rise to heavily scaled castings commonly referred to as 'burnt'.

TABLE II Analyses of fresh and partially spent Cumberland ore and fresh Ouenza ore

	Fresh Cumberland ore %	Partially spent Cumberland ore %	Fresh Ouenza ore %
Fe_2O_3	79·9	9·85	80·2
FeO	Nil	63·50	0·7
MnO	0·14	0·14	2·53
SiO_2	7·50	18·18	3·60
CaO	5·51	3·40	6·68
S	0·01	0·07	0·06

Apart from dealing with temperature and atmospheric conditions in annealing the ironfounder can also control the impurity level in the partially spent ore in circulation to some extent. It is easier to clean impurities from partially spent ore than from fresh kibbles because of changes occurring during annealing. Limestone in the fresh kibbles is burnt to lime which breaks down and tends to be screened from partially spent ore as fines. The major sulphur-bearing impurities also fall into this category and it is definitely beneficial to screen partially spent ore and reject everything passing ½ or preferably $\frac{3}{16}$ mesh. Silica tends to resist breakdown and cannot be removed successfully by screening. Indeed the silica content of an ore generally rises with repeated use.

Weathering of partially spent ore is beneficial. In a moist atmosphere, lime forms calcium hydroxide which may be screened or washed out of the ore with ease. At the same time there is a tendency for the ore to recover some of its oxygen availability, although this requires a few months to produce a significant improvement. This process can be accelerated artificially, with a solution of ammonium chloride. This leads to the formation of ferric chloride with the release of ammonia; and the ferric chloride in turn hydrolyzes to form ferric hydroxide and finally ferric oxide. Although the maximum chloride treatment accelerates the rusting process it is dangerous to use ore so treated while it contains free chloride. Both ammonium and ferric chloride either break down or are leached out of the ore easily by deliberate washing or natural weathering. Use of ore containing large amounts of ferric chloride will result in the release of volatile chlorides in the annealing furnace with consequent corrosion damage to refractories and metal parts.

Another difficulty which the ironfounder can avoid is caused by injudicious mixing of ores of different types. An ore containing an appreciable quantity of silica and another carrying limestone impurity may be perfectly satisfactory when used separately, but if they are mixed or if new ore of the one type is introduced into partially spent ore of the other type, fluxing troubles may be encountered owing to the complementary fluxing action of the combined impurities. This problem is illustrated in Table II, which gives the analysis of a typical Cumberland red ore as fresh kibbles, the average analysis of the partially spent ore in circulation resulting from the use of the Cumberland ore, and a typical analysis of Ouenza hematite which was introduced. A Cumberland ore mixture and an Ouenza hematite mixture were perfectly satisfactory when in use separately but fluxing defects arose when they were mixed.

The effect of such mixing may not be evident in the

TABLE III Analyses of annealing ores investigated. Typical average composition

	Cumberland	Lancashire Whitrigg	Portuguese Freja	Brazilian Itabera	Spanish Orada	N. African Ouenza	N. African Rif	Canadian Wabana
Fe_2O_3, %	78·12	94·80	64·07	97·45	86·4	77·88	82·89	65·85
FeO, %	0·20	0·11	23·41	1·15	ND	0·23	6·32	9·63
SiO_2, %	10·45	1·81	4·81	0·50	6·6	2·72	3·87	10·00
CaO, %	5·35	0·14	1·50	0·07	3·7	4·81	0·75	2·80
MgO, %	0·14	0·07	1·05	ND	2·1	1·08	0·60	0·40
Al_2O_3, %	4·25	ND	0·98	0·42	0·4	0·47	1·57	ND
MnO_2, %	0·14	ND	ND	ND	ND	2·38	ND	ND
S, %	0·012	0·03	0·054	0·006	0·13	0·040	0·24	0·31
PO_4, %	0·007	ND	ND	0·09	ND	0·01	ND	2·135
Ign. loss	5·32	ND	1·05	0·60	ND	ND	ND	ND

ND=Not determined

first annealing heat but further additions of the new type of ore, containing limestone in the example given above, may raise the combined impurity levels above the safe limits. Table II also illustrates the build-up of silica and sulphur and decrease in lime content in the partially spent ore compared with the fresh ore, due to screening.

Strict attention by the whiteheart malleable iron-founder to the detailed control of the annealing process as outlined above would undoubtedly reduce the number of annealing defects very considerably. At the same time a consistently high quality of annealing ore at an economical cost is obviously desirable. Two methods of attempting to achieve this are: (i) to select an ore as-mined which is of high quality and also suitable for annealing; (ii) to dress an ore in order to improve its quality for annealing.

EXAMINATION OF IRON ORES FOR ANNEALING PURPOSES

A variety of ores have been examined with a view to determining their suitability in the annealing process. Tests can be applied to the ore in kibble form in order to assess its suitability approximately, but final suitability can be proved only by full-scale industrial tests under well controlled conditions. A chemical analysis is frequently informative and Table III gives the analysis or range of ores examined by the authors in recent years. Generally speaking the impurities to be avoided are silica, limestone, sources of sulphur such as pyrites and barytes, and fluorides. The amounts of any of these impurities which can be tolerated vary with the ore. Precise limits on composition of the annealing ore, annealing temperatures, and times to avoid fluxing defects are not known. The number of variables which may affect the process is too great to allow more than a general survey of the factors which cause fluxing defects. It is certain that the tendency to form fluxing defects increases with (i) annealing temperature, (ii) annealing times, (iii) decreasing decarburizing power of the ore, (iv) increasing silica, lime, and fluoride content of the ore.

The severity of attack is largely controlled by the amount and type of slag created from constituents of the ore. Slags are more likely to be created from fine particles of impurities if their surfaces are freely open to reaction. Fine impurities disseminated within larger particles of hematite do not seem to be so harmful, but screening out of all fines from annealing ore is beneficial in avoiding slag formation.

Palmer[4] suggests when ore is contaminated with more than 4% limestone and with fluorspar, sticking is possible, particularly if the silica content exceeds 10% at the same time. He quotes the analysis of a slag which caused serious ore adhesion as 5·6%Fe; 21·41%FeO; 2·56%Fe_2O_3; 11·05%CaO; 1·87%F; 50%SiO_2. Ternary and quaternary combinations of the components CaO; FeO; CaF_2; SiO_2; Al_2O_3 can form liquid slags at temperatures of the order of 1000–1100°C and even simple binary combinations may be liquid at temperatures which might exist in annealing cans situated close to the flame. The presence of a slag can explain the poor decarburization of the castings in that it acts as a barrier between the carbon at the casting surface and the decarburizing atmosphere. On the other hand, the surface carbon will be in contact with ferrous oxide at the scale/slag interface. The carbon could reduce the ferrous oxide to iron in the solid state, this iron allowing diffusion of carbon to its surface and so on. Gradually a ferrous oxide rich slag could be converted to a spongy but solid iron particle very firmly welded to the casting.

In the presence of sulphur, either in the ore mixture or in the furnace atmosphere, the slag layer formed may contain ferrous sulphide, and its melting point is likely to be lowered as a result. The eutectic between ferrous oxide and ferrous sulphide melts at 920°C. Other contaminants in the ore such as magnesia appear to have less effect than those mentioned above. Magnesia is most likely to be associated with lime, having arisen from the calcination of dolomitic limestone in the new ore.

Other quality requirements of annealing ore include resistance to spalling, little tendency to produce fines during crushing by the supplier or in handling by the annealer, and a suitable rate of reaction during annealing. Production of fines during crushing is undesirable because it wastes otherwise useful hematite at sizes unsuitable for annealing. Spalling during annealing also produces fines and is undesirable. The rate of reaction in annealing may be assessed from small-scale annealing trials in the laboratory, designed to simulate works practice and using standard test bars in place of castings on which to base the assessment. With these quality requirements under consideration, kibble samples of the ores listed in Table III have been examined to determine their suitability for annealing purposes.

The available oxygen content varies from about 22% in the Canadian, Wabana ore to over 29% in the Brazilian ore. Only the home-produced ores could be described as relatively cheap but of the imported ores the Ouenza ore is also moderately cheap although it is somewhat variable in quality. Rif has the unusual

disadvantage of a dangerously high initial sulphur content while the Itabera and Wabana ores examined tend to produce a high proportion of fines during annealing. Only the Freja ore sample was amenable to magnetic cleaning in the as-received state because it is a magnetite ore. Both Rif and the Wabana ore are somewhat magnetic but not sufficiently so to allow successful cleaning. The Brazilian (Itabera) ore had the highest purity and available oxygen content but was not completely satisfactory. It appears to be too reactive, quickly becomes spongy during annealing, and produces an abnormally large amount of fines. Since it is also expensive the rapid deterioration renders the ore rather uneconomical compared with home-produced ores. Thus high purity in the ore is no guarantee of successful and economical annealing. Reference to the above comments on a variety of ores illustrates the difficulty of replacing the Cumberland ores with a satisfactory, economical, and readily available substitute.

IMPROVEMENT OF ANNEALING ORE QUALITY

Hematite for annealing purposes is used in a range of sizes less than ½in; 60 kibble ore is about ⅜in–½in; 70 kibble, ¼in–⅜in; and 80 kibble $\frac{3}{32}$in–¼in. If fairly massive lumps of gangue are present in as-mined hematite then in crushing the latter to kibble sizes the gangue will also be reduced to discrete particles of the same size range. Since the gangue particles will frequently become stained by the hematite they will be almost indistinguishable in appearance from the hematite. Any hand-picking of gangue from the ore can be done only before crushing and even then it is not an efficient process. In certain deposits gangue is mined with the hematite in discrete lumps. In the Cumberland deposits sandstone occurs in a weakly bonded form, red-stained throughout and having a density of about 2·50. This material commonly contains less than 5% iron (7%Fe_2O_3) but on casual inspection appears similar to hematite. Being relatively friable, this type of rock would tend to crush to fines and be taken out to a large extent in screening. On the other hand silica can be present in a massive crystalline form which is easier to recognize because it is fairly pure but after crushing it remains in the annealing ore as discrete kibbles. Similarly, limestone may occur in the as-mined ore in a form which varies from a relatively soft aggregate with a density of 2·67 to almost perfectly formed calcite crystals with a density of 2·91. An additional complication occurs when the softer forms of limestone are contaminated with carbonaceous matter which blackens them considerably although they may still contain more than 86% calcium carbonate.

There is a possibility of dealing with coarse aggregates of impurities in hematite either by handpicking the lump ore or dressing either lump or kibbled ore but it is virtually impossible to separate the impurities when they are present as thin veins in the hematite or in finely disseminated form. Finely disseminated silica and calcite may be distributed in a manner which can be seen on close inspection but the colour of the lump would be such as to pass as high-grade hematite during hand-picking. Assuming the impurities to be finely distributed, crushing to kibble sizes will alter neither the appearance nor the density of the individual particles.

MINERAL DRESSING TECHNIQUES

No mineral dressing technique treating a size range below that of the annealing kibbles is applicable since, even if successful, the fine hematite concentrate would be unsuitable for annealing purposes and no economical method of agglomerating the fines into the kibble sizes is known. This limitation excludes the techniques of flotation, tabling, and high intensity magnetic separation. Theoretically, high intensity magnetic separation is attractive for cleaning hematite, and low intensity fields may be used to clean magnetite. The magnetic permeability of hematite, relative to pure iron rated at 100, is 1·32 and the permeabilities of quartz and calcite are 0·37 and 0·03 respectively. In practice, the method is unsatisfactory because the hematite must be crushed very small to separate the impurities from the hematite completely, particularly if the impurities are finely disseminated, and also the very high intensity magnetic field can be created economically only across a very small gap, considerably smaller than the kibble sizes.

Rejecting high intensity magnetic separation as a means of cleaning hematite ore in kibble sizes it remains to consider gravity concentration methods such as jigging or heavy medium separation. Both methods depend on differences in density to achieve separation while jigging is additionally dependent on size.

In heavy medium separation the ore is treated in a fluid having an effective specific gravity intermediate between the densities of the minerals to be separated. Close sizing of the feed is unnecessary and the sizes of ore which may be treated by the process may be as large as several inches or as small as 0·1in. In the case of iron ores, the valuable mineral is recovered as the 'sink' and the waste, or possibly material for re-crushing and retreating appears in the 'float'. The method requires less difference in the densities of the minerals to be separated than any other gravity method, but if the densities are very different, so much the better. The medium in commercial work consists of a suspension of fine dense particles in water. Such suspensions have a high effective specific gravity. Typical materials are fine magnetite (effective sp. gr. of medium, 2·5) and ferro-silicon (2·5–3·5 according to composition) ground usually to less than 0·006in. The usual suspensions contain about 50–70% solids by weight.

Pure hematite has a theoretical density of 5·0 but natural hematite, as-mined, frequently has a density not much greater than 4·0 (and yet analyses 95% Fe_2O_3), due to the loose natural formation of the ore. Silica as quartz has a density of 2·5–2·8 and limestone, 2·6–2·7. Thus a separating medium with a density of about 3·1 should be suitable to separate off all free silica and limestone. The precise density of the separating medium and the most economical size of feed required would have to be found by experiment.

The most serious drawback of the heavy medium technique is the recovery of the heavy medium from the iron ore concentrate. This would necessitate thorough washing to clean the kibbles followed by drying. The washings containing entrained heavy medium would have to be settled or filtered in order to recover the solids so that these may be returned to the heavy medium stock tank. Although the tailings are likely to be useless, they also will have to be washed

TABLE IV Analyses of fractions of Ouenza and a north-west coast hematite after jigging concentration

Cumberland hematite		Ouenza hematite	
Concentrate: 38·6% by wt		Concentrate: 34·4% by wt	
S, %	0·13	S, %	0·062
Fe_2O_3, %	92·57	Fe_2O_3, %	76·50
SiO_2, %	3·42	SiO_2, %	1·90
CaO	Trace	CaO, %	4·0
Sp. gravity	4·3	Sp. gravity	3·62
Middlings: 34·8% by wt		Middlings: 33·9% by wt	
S, %	0·010	S, %	0·042
Fe_2O_3, %	85·41	Fe_2O_3, %	75·89
SiO_2, %	4·74	SiO_2, %	1·50
CaO, %	2·46	CaO, %	4·40
Sp. gravity	3·87	Sp. gravity	3·57
Tailings: 26·6% by wt		Tailings: 31·7% by wt	
S, %	Nil	S, %	0·029
Fe_2O_3, %	52·51	Fe_2O_3, %	71·50
SiO_2, %	19·01	SiO_2, %	2·96
CaO, %	10·57	CaO, %	5·91
Sp. gravity	2·96	Sp. gravity	3·34

free of heavy medium. This extra washing process on both concentrate and tailings together with drying of the concentrate removes much of the attraction of the process for economic reasons.

The other gravity concentration method, jigging, would also operate most efficiently on material already screened to kibble sizes. These sizes will give the maximum degree of separation of gangue from hematite during the crushing operation that can be allowed. Jigging of closely sized material, such as a kibble range, means that separation will be dependent on the difference in the specific gravity of the particles and not on size. The criterion determining whether a jigging operation is likely to be successful or not is established and the likely efficiency of the process applied to a given ore may be determined from simple laboratory tests. If the ratio

$$\frac{\text{density of iron oxide} - 1 \text{ (sp. gr. water)}}{\text{density of waste} - 1 \text{ (sp. gr. water)}}$$

is greater than 2·0, then jigging is likely to produce a useful separation. Thus, from the densities quoted above for hematite and major impurities jigging is likely to be successful, but will not separate barytes (sp. gr. about 4·4) from the hematite kibbles.

Jigging trials were carried out on Cumberland ore and Ouenza ore kibbles. Jigging of Cumberland ore was effective since most of the impurities were present as discrete particles but the process also resulted in a concentration of barytes with the hematite. Additionally, more than 25% of the as-received kibbled ore was rejected into the tailings and these carried more than 50% of Fe_2O_3. This would inevitably result in a substantial increase in the cost of suitable kibbles for annealing. Jigging of Ouenza ore was not effective because the impurities were finely disseminated through individual kibbles of hematite. Table IV illustrates typical results of jigging Cumberland and Ouenza ores in the 70 kibble size range.

It has been pointed out that even high intensity magnetic separation was ineffective in concentrating fresh hematite in usable kibble sizes but partially spent ore is highly magnetic and may be cleaned with low intensity magnetic fields. Since the bulk of the fluxing problems in annealing arise because of accumulation of impurities in the spent ore which may be recycled, it follows that considerable improvements in performance could be obtained by magnetic cleaning of partially spent ore.

TABLE V Chemical analyses and weights of products obtained by magnetic concentration of Cumberland and Ouenza ore returns (including the analysis of the *original fresh ores*)

	% of products	Fe, %	FeO, %	Fe_2O_3, %	SiO_2, %	CaO, %	S, %
Cumberland							
Fresh hematite				73·25	14·24	4·34	0·049
Returns	100	42·5	28·5	3·2	16·36	3·14	0·092
Magnetic concs.	83	44·0	27·0	1·6	10·46	2·63	0·088
Magnetic tailings	17	1·86	27·4	5·4	37·6	8·41	0·062
Ouenza							
Fresh hematite				76·84	2·3	5·32	0·056
Returns	100	39·0	32·4	2·88	7·03	4·57	0·086
Magnetic concs.	77	50·0	25·0	1·6	6·28	2·91	0·034
Magnetic tailings	23	6·24	52·6	8·0	8·97	8·77	0·35

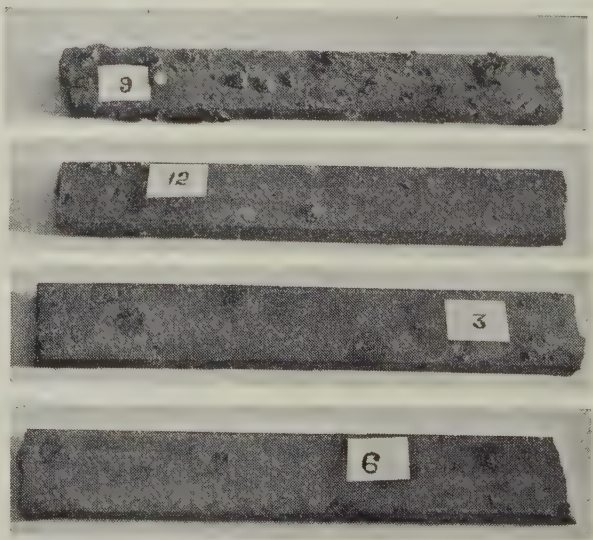
TABLE VI Degree of ore adhesion on annealed bars

Mix no.				Annealing temperatures, °C 1100	1070	1040	1000
1.	Fresh Ouenza	Ouenza returns	1:4	*C*	*C*	*C*	*D*
2.			1:5	*C*	*C*	*C*	*D*
3.			1:6	*C*	*C*	*C*	*D*
4.	Fresh Ouenza	Magnetically cleaned Ouenza returns	1:4	*D*	*D*	*C*	*E*
5.			1:5	*D*	*D*	*C*	*E*
6.			1:6	*D*	*D*	*C*	*E*
7.	Fresh Cumberland	Cumberland returns	1:4	*A*	*B*	*B*	*D*
8.			1:5	*A*	*B*	*B*	*D*
9.			1:6	*A*	*B*	*B*	*D*
10.	Fresh Cumberland	Magnetically cleaned Cumberland returns	1:4	*B*	*B*	*C*	*D*
11.			1:5	*B*	*B*	*C*	*D*
12.			1:6	*B*	*B*	*C*	*D*

A Severe sticking of the welded-on type
B Sticking—slag adhesion of ore particles
C Slight sticking
D Very slight sticking
E Very slight to no sticking

EXPERIMENTAL WORK

For the purpose of comparison, two ores were chosen: a typical Cumberland hematite ore and the North



Mix no.	9	12	3	6
Degree of adhesion	*A*	*B*	*C*	*D*

1 *Appearance of bars annealed at 1100°C*

TABLE VII Results of bend tests measured in degrees of arc (Averages of duplicate test results)

Mix no.†	Annealing temperatures, C 1100	1070	1040	1000
1	110*	107	110	125
2	119	(89)*	60*	91
3	120	110	107	113*
4	131	118	117	130
5	128	115	114	129
6	132	115	115	127
7	118	112	119	92*
8	122	113	113	117
9	137	115	112	112
10	123	123	120	115
11	126	120	116	95
12	133	129	117	115

* One or both specimens probably cracked through casting defect, in regions of sticking and pitting

† For component ratios, *see* Table VI.

TABLE IX Carbon lost by test bars compared with changes in weight during annealing

Temp., °C	Mix no.*	Wt of bars, g Before	After	Decrease, g	% loss in carbon during annealing	Wt loss due to carbon, g
1100	2	456	442	14	2·92	13·3
	5	463	452	11	3·03	14·0
	8	456	(473)	...	3·20	14·6
	11	456	446	10	3·15	14·4
1070	2	492	477	15	3·03	14·9
	5	467	451	16	3·16	14·8
	8	454	440	14	3·23	14·6
	11	488	473	15	3·20	15·6
1040	2	460	448	12	2·66	12·2
	5	406	394	12	2·93	11·9
	8	448	434	14	3·08	13·8
	11	444	429	15	3·03	13·4
1000	2	438	427	11	2·33	10·0
	5	453	441	12	2·60	11·4
	8	451	439	12	2·67	12·0
	11	465	452	13	2·55	11·9

* For component ratios *see* Table VI.

African Ouenza ore, both in the 70 kibble size ($\frac{1}{4}$–$\frac{3}{8}$in). Both ores contained substantially the same amount of ferric oxide and consequently had similar total impurity levels. In the Cumberland ore the gangue was present as discrete particles but in the Ouenza ore the impurities were mainly present as fine dispersions within the ore kibbles. Therefore, it was thought that magnetic cleaning of returned ore from Cumberland sources would be more effective than treatment of returned ore from Ouenza sources. The results reported in Table V confirm this.

Having demonstrated that magnetic concentration could decrease the harmful impurities in the returned ore, the next step was to use the cleaned ore in annealing experiments to compare both its decarburization potential and possible difficulties (e.g. sticking) with uncleaned returned ore mixtures. For these trials it was decided to use test bars (7in × 1in × $\frac{1}{2}$in) of the following composition: 3·38%C, 0·43%Si, 0·27%Mn, 0·14%S. These bars were packed in the prepared ore mixtures in rectangular welded steel boxes (8in × 2in × 2in) with lids luted on with alumina cement before placing in the furnace.

The ore mixtures were prepared as in industrial annealing plants, on the basis of volume, using three mixture strengths. Four annealing temperatures were used, 1000, 1040, 1070, and 1100°C and the annealing cycle involved 8 h heating to 700°C, 16 h at 700°C, and 12 h heating to one of the annealing temperatures which was held for 60 h for the three lower annealing temperatures but only 33$\frac{1}{2}$ h at 1100°C. Controlled cooling to 600°C took 8 h and finally natural furnace cooling was allowed to room temperature before unloading the boxes. The furnace used was a silicon carbide electric resistor furnace and the external atmosphere to the boxes was air, thus eliminating possible complications due to peeling defects caused by sulphur from combustion gases.

Each box was emptied separately and the state of the bars noted, especially from the point of view of ore adhesion, with the results shown in Table VI and photographic evidence presented in Fig.1. When adhered particles had been removed the bars were weighed, and then bend tested according to BS.309: 1958; the results being shown in Table VII. The ore was weighed and sampled for analysis which gave the results in Table VIII, together with the respective analyses (calculated) before annealing.

After carrying out the bend tests the bars were drilled throughout for carbon analyses, and sectioned for microscopic examination. The results of typical carbon determinations are shown in Table IX together with the changes in weight of the test-bars. Table X records the depth of ferrite rim on each of the annealed bars. The results of the X-ray diffraction analysis on appropriate ore samples are recorded in Table XI.

TABLE VIII Changes in ore analyses during annealing

Temp., °C	Mix, no.†	Analysis before annealing* S	SiO_2	CaO	Fe	FeO	Fe_2O_3	[O]	Analysis after annealing Fe	FeO	Fe_2O_3	[O]
1100	2	0·082	6·3	4·7	33·2	27·6	14·0	10·3	38·4	32·8	3·8	8·4
	5	0·037	5·7	3·3	42·5	21·2	12·9	8·6	49·5	21·6	4·2	6·1
	8	0·084	16·0	3·4	34·2	23·0	16·8	10·1	45·1	24·7	0·3	5·6
	11	0·081	11·2	3·0	35·8	22·0	14·9	9·4	51·4	22·4	1·0	5·3
1070	2	0·082	6·3	4·7	33·2	27·6	14·0	10·3	38·4	31·6	6·1	8·9
	5	0·037	5·7	3·3	42·5	21·2	12·9	8·6	45·5	25·0	7·0	7·7
	8	0·084	16·0	3·4	34·2	23·0	16·8	10·1	43·0	31·4	1·0	7·3
	11	0·081	11·2	3·0	35·8	22·0	14·9	9·4	50·5	25·3	3·2	6·6
1040	2	0·082	6·3	4·7	33·2	27·6	14·0	10·3	36·7	31·6	5·4	8·6
	5	0·037	5·7	3·3	42·5	21·2	12·9	8·6	51·4	22·8	4·5	6·4
	8	0·084	16·0	3·4	34·2	23·0	16·8	10·1	48·6	23·0	2·2	5·8
	11	0·081	11·2	3·0	35·8	22·0	14·9	9·4	52·4	21·9	2·2	5·5
1000	2	0·082	6·3	4·7	33·2	27·6	14·0	10·3	25·9	37·1	12·8	12·1
	5	0·037	5·7	3·3	42·5	21·2	12·9	8·6	37·6	25·6	10·5	8·8
	8	0·084	16·0	3·4	34·2	23·0	16·8	10·1	41·7	27·0	5·8	7·7
	11	0·081	11·2	3·0	35·8	22·0	14·9	9·4	39·0	29·4	7·4	8·8

* Calculated. † For component ratios, *see* Table VI.

TABLE X Depth of ferrite rim on typical annealed bars

Bar from mix no.*	Depth of ferrite × 10^2 in† 1100°C	1070°C	1040°C	1000°C
2	2·2	3·1	2·0	1·9
5	2·5	3·9	2·2	2·5
8	4·4	5·2	3·5	2·4
11	4·0	5·3	3·2	2·5

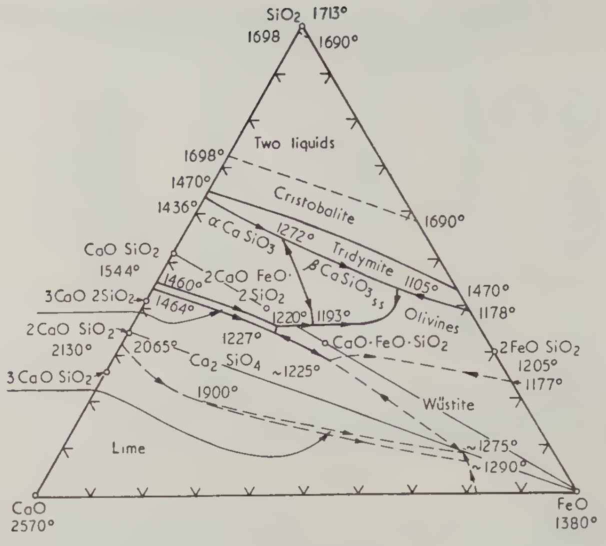
* For component ratios, *see* Table VI.
† Measurements were made from each side of the annealed bars and averaged. The reproducibility within a given bar was ±0·002in.

DISCUSSION

Referring to Table V, magnetic cleaning of Ouenza returned ore resulted in a concentration of metallic iron, but a decrease in ferrous oxide and ferric oxide contents, sulphur content, lime, and silica contents. Similar cleaning of Cumberland returned ore produced an insignificant increase in metallic iron content, insignificant changes in ferrous oxide, sulphur, and lime contents, but a pronounced decrease in silica content was evident, presumably because silica in typical Cumberland ore is present as discrete kibble sized particles. The magnetic concentration depended on the presence of metallic iron rather than on magnetic iron oxide, Fe_3O_4. Table XI shows, in fact, that magnetite was not present in significant quantities in any of the returned ore samples examined. There appears to be little practical advantage to be gained from magnetically treated returned ore from Ouenza sources. This is emphasized when the proportion of material (23%) rejected as tailings is taken into consideration. On the other hand, the proportion of Cumberland tailings (17%) was less and the magnetic separation did result in a significant improvement from the point of view of sticking tendencies. This is illustrated by Table VI and Fig.1. However, it should be noted that Ouenza ore mixtures were significantly less prone to causing sticking than the Cumberland ore mixtures at all temperatures. If the X-ray results in Table XI are examined it is apparent that the major difference between the Cumberland and Ouenza returned ores is the presence of a significant amount of fayalite ($2FeO.SiO_2$) in the Cumberland returned ore sample, whereas the iron oxide is present in the Ouenza ore as wüstite (FeO). When the Cumberland returns were magnetically cleaned, most of the fayalite was rejected into the tailings and the concentrate was then less prone to cause sticking. Thus, one of the most important constituents causing sticking when Cumberland returns are used appears to be fayalite. In the pure state, fayalite has a melting point of about

TABLE XI X-ray examination results

Ore	Material	Constituents present
N. African Ouenza	Returns	α-iron and wüstite (probably more FeO than Fe) with various unidentifiable faint lines
	Magnetic concs.	Mainly α-iron. Some wüstite. Traces of silica (fayalite and Fe_2O_3 not present in sufficient quantity to be identified)
	Tailings	Mainly wüstite. Some α-iron. Traces of α–SiO_2, Fe_2O_3, and fayalite
Cumberland	Returns	α-iron and fayalite. Very faint traces of free quartz
	Magnetic concs.	Lot of α-iron. Little fayalite
	Tailings	Fayalite with α-iron and silica



2 CaO–SiO_2–FeO *equilibrium diagram*

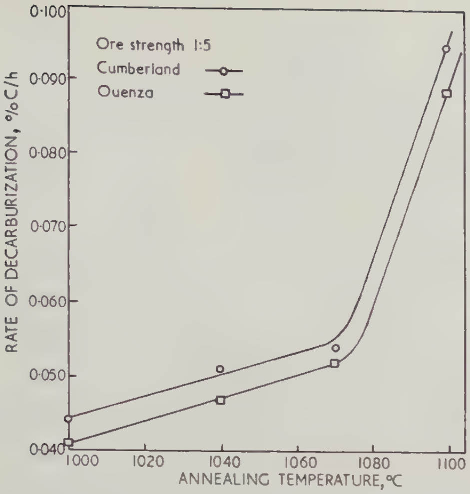
1200°C, but free silica was observed in the X-ray diffraction pattern of the Cumberland returns. The chemical analysis shows the presence of lime and ferric oxide. The composition of the Cumberland returns, concentrates, and tailings are summarized in Table XII, first in full, and secondly the returns recalculated, after neglecting the free iron content, on a basis of slag constituents only. It will now be apparent that the combined effect of the slag constituents will be to form a ternary or more complex eutectic of fayalite: calcium orthosilicate and silica which has a melting point of 1105°C, (*see* Fig.2). The actual melting point of the complex is likely to be lower still since additional impurities are present and under these circumstances a liquid slag, based primarily on fayalite, could exist at temperatures encountered in annealing practice. The importance of the magnetic cleaning of Cumberland returned ore, centres on the rejection of most of the fayalite and free silica into the tailings. It is worth noting that this is achieved at the expense of rejecting only 17% of the returned Cumberland ore as tailings. In Ouenza ore, the fact that the silica in the ore is finely dispersed, means that, of the small proportion of fayalite which can be formed, only that formed at the surface of the ore particles can cause adhesion. The presence of discrete particles of silica in the Cumberland ore, and their relatively high proportion, means that much more fayalite can form at the surface of the ore particles where it can do most harm.

From Table IX, the carbon lost by the test bars, using an average ore mixture strength of 1 part new to 5 parts returned ore in a given time, can be related to temperature of annealing. Figure 3 plotted on this

TABLE XII Composition of Cumberland returns (magnetic concentrates and tailings *assuming the presence of fayalite* ($2FeO.SiO_2$))

	Free SiO_2, %	$2FeO.SiO_2$, %	Fe, %	Free FeO, %	Fe_2O_3, %	CaO, %
Returns*	4·5	40·4	42·5	...	3·2	3·14
Magnetic concs.	...	35·7	44·0	1·9	1·6	2·63
Tailings	26·2	38·8	1·86	...	5·4	8·41

* Returns recalculated neglecting free Fe. SiO_2, 8·2%; $2FeO.SiO_2$, 74·0%; Fe_2O_3, 5·9%; CaO, 5·7%.



3 *Effect of annealing temperature on the overall rate of decarburization*

basis shows that the Cumberland mixture has a significantly higher decarburizing effect than the Ouenza mixture at all temperatures. Also the depth of ferrite rim recorded in Table X shows the greater decarburizing efficiency of Cumberland ore mixtures, in spite of the insignificant difference in the bend test results for castings annealed in either type of mixture (Table VII). If anything, the average bend test figures using the Cumberland ore are slightly better than those obtained using the Ouenza ore mixtures but this is probably not significant. Table X also shows that in no case did magnetic cleaning of returned ore reduce the rate of decarburization of the castings. Indeed, particularly with Cumberland ore mixtures at 1100°C, the rate of decarburization was increased when cleaned returns were used instead of uncleaned returned ore. Part of this improvement is probably due to the lower tendency to form fayalite which is less reactive than wüstite in regenerating CO_2, and part to the reduced tendency to form slag on the castings which restricts carbon diffusion through the surface.

The ferric oxide content of the Cumberland ore mixtures was comparable with that of the corresponding Ouenza ore mixtures at the beginning of the annealing cycle (*see* Table VIII). Since the same batch of test bars was used with both ore mixtures the difference in decarburization cannot be due to differences in carbon diffusion at any given temperature. The superior decarburizing efficiencies of the Cumberland ore mixtures must therefore be due to their inherently greater reactivity.

From the X-ray examination the ratio of ferrous oxide to silica for fayalite formation in the case of Cumberland ore suggested that there was little or no free ferrous oxide at the end of the soaking period (*see* Table XII). This combination of ferrous oxide and silica to produce fayalite would tend to restrict the regeneration of the carbon dioxide in the gas atmosphere at the ore surface, but it would still produce a CO/CO_2 gas mixture which was oxidizing to carbon at the surface of the casting (*see* Appendix). However, it has been shown that Cumberland ore mixtures decarburize the castings at a faster rate and, therefore, it would appear that the returned ore part of the mixtures, which would consist mainly of fayalite and free metallic iron, must play a very insignificant part in the decarburizing process. It can be shown that there is sufficient oxygen added in the fresh ore part of the ore mixtures used, to achieve the actual decarburization produced. Therefore, the value of recycling return ore for its oxygen content is open to question and since the returned ore contained the strongly fluxing material fayalite it would seem that no advantages can accrue from its inclusion and in fact very dangerous fluxing tendencies can ensue.

Finally, it is apparent from Fig.3, that if sticking problems can be eliminated and adequate support given to the castings to avoid distortion, the rate of decarburization at 1100°C, particularly with a relatively reactive ore, is attractively high and could lead to significant shortening of annealing cycles.

CONCLUSIONS

1. Many of the problems which have arisen in annealing whiteheart malleable irons in the ore process can be traced to inadequate control on the part of the annealer. The control items which require particular attention are temperature level and distribution in the furnace; the ratio of partially spent to new ore; furnace atmosphere; thorough cleaning of the partially spent ore; and avoiding mixtures of ores of different types.

2. Several possible alternative ores to the widely used Cumberland hematite have been examined but no perfectly satisfactory substitute can be recommended without reservation. The possibilities of improving the quality of several ores have been examined. Magnetic cleaning of hematite in the sizes used for annealing is not feasible and heavy medium separation which may be partially successful with certain ores is not likely to be economical. Similarly, jigging is successful in some respects but it is likely to reject a bulky tailing, thus making the concentrate expensive, and has a distinct tendency to increase the sulphur content of the concentrate. This would increase the incidence of peeling defects at the expense of fluxing defects.

3. Ore adhesion during annealing of whiteheart malleable iron castings is more serious with ores containing the gangue particles, particularly silica, as discrete particles; e.g. as in Cumberland ore, than with ores containing impurities finely disseminated throughout the ore kibbles, as in Ouenza ore. Ore adhesion increases with increasing annealing temperature and is probably due to the formation, particularly with Cumberland ore mixtures, of fusible slags, based on fayalite, $2FeO.SiO_2$.

4. Magnetic cleaning of returned ores decreases the tendency for ore adhesion without decreasing the rate of decarburization of the castings. The magnetic cleaning method is most effective on returned ore derived from hematite containing gangue as discrete particles, and is dependent on the presence of metallic iron in the spent ore. The oxygen potential of the spent ore is slightly reduced by the cleaning process but this does not appear to affect the decarburizing efficiency of an ore mixture containing cleaned spent ore.

5. The value of spent ore, which is normally reused in subsequent annealing cycles, is doubtful from the point of view of its contribution to the decarburization

process, whereas it undoubtedly adds to the problem of ore adhesion. The possibility of replacement of spent ore with a relatively inert ballast material should be examined. Two of the authors have work in hand examining the use of inert ballast material instead of partially spent ore and it is hoped that the results may be made available for publication.

ACKNOWLEDGEMENT

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APPENDIX

FeO–Fe, CO–CO_2 *equilibrium atmospheres*

The annealing atmosphere which is in equilibrium with ferrous oxide can be calculated for any temperature from the Gibbs-Hemholtz equation

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

The relevant data for the variation of ΔG° in calories with temperature T between 25°C and 1 100°C are:

(1) $C+O_2 \rightleftharpoons CO_2 \quad \Delta G^\circ_1 = -94\,200-0{\cdot}20T$

(2) $C+\frac{1}{2}O_2 \rightleftharpoons CO \quad \Delta G^\circ_2 = -26\,700-20{\cdot}95T$

(3) $Fe+\frac{1}{2}O_2 \rightleftharpoons FeO \quad \Delta G^\circ_3 = -62\,050+14{\cdot}95T$

From (1) and (2) we can obtain

(4) $CO+\frac{1}{2}O_2 \rightleftharpoons CO_2 \quad \Delta G^\circ_4 = -67\,500+20{\cdot}75T$

and from (3) and (4)

(5) $FeO+CO \rightleftharpoons Fe+CO_2 \quad \Delta G^\circ_5 = 5\,450-5{\cdot}80T$

But

$$\Delta G^\circ_5 = -RT \ln K_T \text{ where } K_T = \frac{a_{Fe}\cdot P_{CO_2}}{a_{FeO}\cdot P_{CO}}$$

Assuming the activities of Fe and FeO are unity

$$K_T = \frac{PCO_2}{PCO}$$

Then

$$\Delta G^\circ_5 = -4{\cdot}575\ T \log_{10} \frac{PCO_2}{PCO}$$

Therefore

$$\frac{PCO_2}{PCO} = \log^{-1} \frac{5{\cdot}450-5{\cdot}80T}{4{\cdot}575T}$$

where T°K is the annealing temperature.

From the above equation the equilibrium CO_2/CO ratios were calculated and are shown below.

Temperature, °C	$\%CO_2$	$\%CO$
1100	28·4	71·6
1070	29·2	70·8
1040	30·2	69·8
1000	31·6	68·4

Thus, at 1000°C gases containing more than 68·4%CO will reduce pure wüstite (FeO) whereas at 1100°C the carbon monoxide must be more than 71·6%.

However, it has been shown in the report that in the Cumberland ore mixtures the FeO was present as fayalite and not pure wüstite. The following calculation shows how this affects the CO/CO_2 ratios necessary to reduce fayalite to produce the required annealing atmosphere and the reduced oxidizing potential (i.e. oxygen partial pressure) which ensues.

In the previous calculation a_{FeO} was assumed to be unity but, in the case of fayalite, this activity is about 0·65; and therefore:

$$\frac{PCO_2}{PCO} = \log^{-1} \frac{0{\cdot}65\ (5{\cdot}540-5{\cdot}80T)}{4{\cdot}575T}$$

From this new equation the following equilibrium CO_2/CO ratios were calculated.

Temperature, °C	$\%CO_2$	$\%CO$
1100	23·3	76·7
1000	20·5	79·5

The oxidizing potential of the CO_2/CO ratios calculated may be obtained from the equation (4) above.

$CO+\frac{1}{2}O_2 \rightleftharpoons CO \quad \Delta G^\circ_4 = -67\,500+20{\cdot}75T$

as before $\Delta G^\circ_4 = -RT \ln K_T$

where $K_T = \dfrac{PCO_2}{PCO.P^{\frac{1}{2}}O_2}$

Therefore

$$\frac{PCO_2}{PCO.P^{\frac{1}{2}}O_2} = \log^{-1} \frac{67\,500-20{\cdot}75T}{4{\cdot}575T}$$

From this equation it may be shown that for an annealing temperature of 1027°C the partial pressure of oxygen over pure wüstite (FeO) is about $0{\cdot}5\times10^{-14}$ atm but over fayalite it is only $0{\cdot}2\times10^{-14}$ atm (approx.). This means that the oxidizing potential of the gases has been reduced by nearly 60% if the ferrous oxide is present only as fayalite.

The universal beam and heavy structural mill at the Lackenby works of Dorman Long (Steel) Ltd

A. P. Clark, B.Sc., and R. E. Kenderdine, B.Sc., A.M.I.E.E.

PART 1 MECHANICAL SECTION

SYNOPSIS

The universal beam and heavy structural mill at Lackenby has been designed to produce 10000 tons/week of a comprehensive range of universal beam and column sections, generally with wider flanges, and a higher strength to weight ratio, than British Standard beams.

In the mill design, several novel features have been incorporated, notably (a) *by a simple change of roll stands, the mill can be converted to roll any BS sections;* (b) *the hot saw measuring gear, push-button controlled, has been designed to keep pace with the mill output, at the same time cutting every bar to the length ordered;* (c) *the cooling banks are arranged in tandem, to facilitate sorting of the sawn bars.* 1940A

THE UNIVERSAL BEAM MILL at the Lackenby works of Dorman Long (Steel) Ltd is the first rolling mill of its kind in operation in the UK. It is unique in that it is capable of rolling not only a complete range of wide flanged beams and columns, but also any of the present range of British Standard sections. In the wide flanged range, the largest beam is 36in$\times$16½in, and weighs 260 lb/ft, while the smallest is 8in$\times$5¼in$\times$ 17 lb/ft. The heaviest column weighs 426 lb/ft. The mill has been designed for a weekly output of about 10000 tons of finished steel.

The layout of the mill is shown in Fig.1. The stripping cranes and soaking pits are in cross bays at the south end, and the main mill bay, 2440 ft long, contains all the mill stands and roller tables. North of the finishing stand are the two hot saws and the cooling and sorting banks, extending into adjacent bays. On the east side of the main mill bay are the two electric houses containing all the main electrical machinery and switchgear, and the roll turning shop and roll stocking racks. East of the main machinery bays is the loading bay, 100 ft span and 2150 ft long.

Ingot stripping and heating

The mill requires a wide range of ingots in six sizes, varying from 4 to 20 tons in weight. For the heaviest ingots there is a stripping crane of 40 tons lifting and 400 tons stripping capacity, and for the smaller ingots a lighter crane to lift 20 tons. After stripping, the ingots are loaded by the same cranes into two rope-hauled transfer cars, which carry them into the soaking pit bay.

The twelve soaking pits are arranged in two batteries of six pits, with the ingot transfer in the middle. They are fired with blast-furnace gas, improved by a small proportion of coke-oven gas. Each pit is 26 ft$\times$ 10 ft$\times$13 ft deep, and the total capacity varies from 1680 tons of 20-ton ingots down to 768 tons of 4-ton ingots. The Austeel–Escher recuperators are designed to give a combined preheat to the gas and air of 1000–1200°C. The two air recuperators, of the parallel flow type, lie horizontally and are followed by the single vertical gas recuperator, which acts as a chimney. The pit covers consist of a simple frame of plates 2½in thick with heavy cross-ties, carrying an arched lining of 12in thick semi-silica bricks and 3in of insulation. Each cover has its own lifting and retracting gear, controlled from the soaking pit crane. When the crane is opposite the selected pit, the driver can open the cover by any desired amount. After the ingot is removed, an impulse from the crane causes the cover automatically to close.

The drivers of the two 20-ton ingot charging cranes not only operate the pit covers, but are in complete control of the removal of ingots from the pits and sending them to the mill. Each driver, by control from his cab, lifts the ingot from the pit, carries it over and places it on the ingot chair leading to the blooming mill. He then initiates a sequence which lowers the chair, starts up the ingot receiving table, and stops the ingot at the weighing machine, where its weight is automatically registered. Only then does the mill operator take over and run the ingot forward to the mill. An ingot being weighed is shown in Fig.2.

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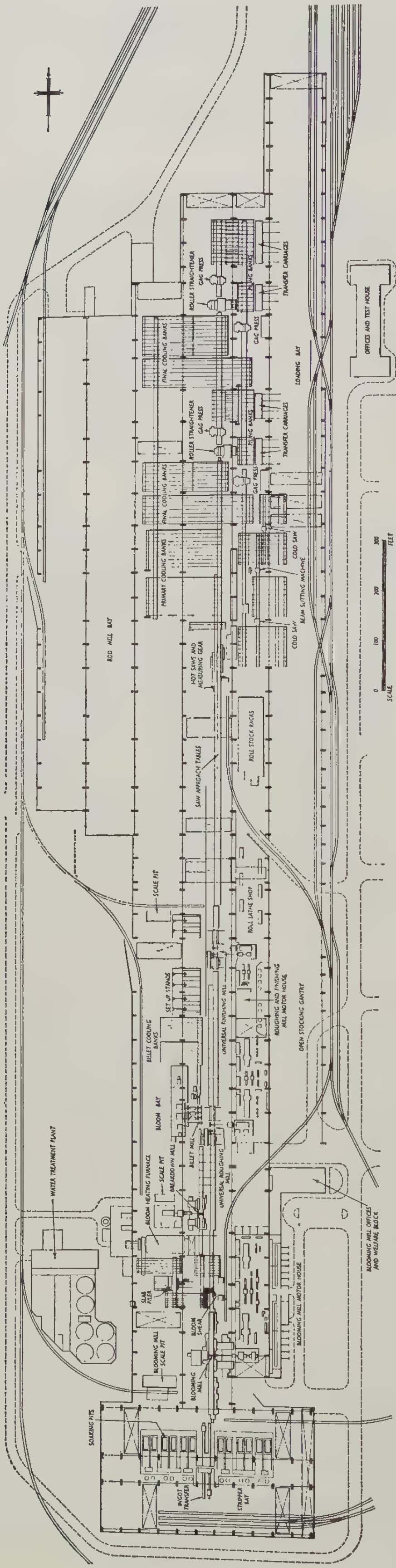
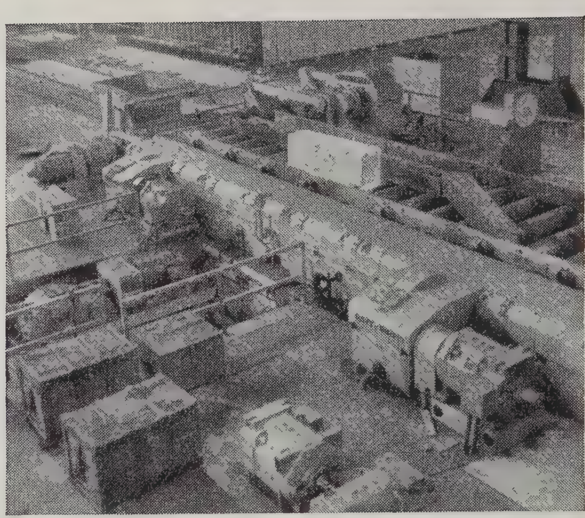
Mr Clark is Chief Design Engineer and Mr Kenderdine Assistant Electrical Engineer of Dorman Long (Steel) Ltd.



1 *Layout of universal beam mill*



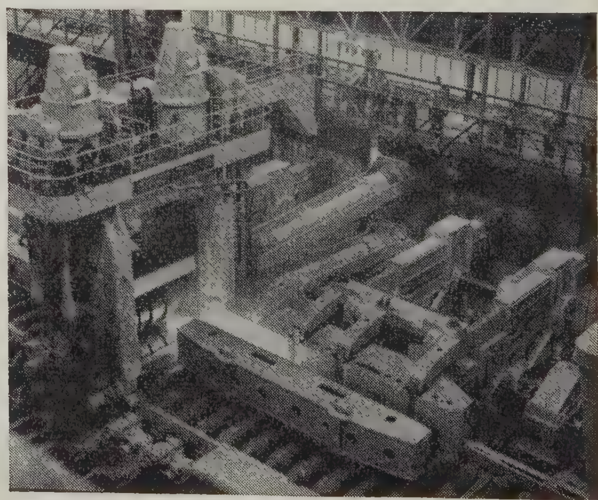
2 *Approach roller table to blooming mill. In the background are the soaking pits, and the tracks for the ingot transfer cars*

52-in blooming mill

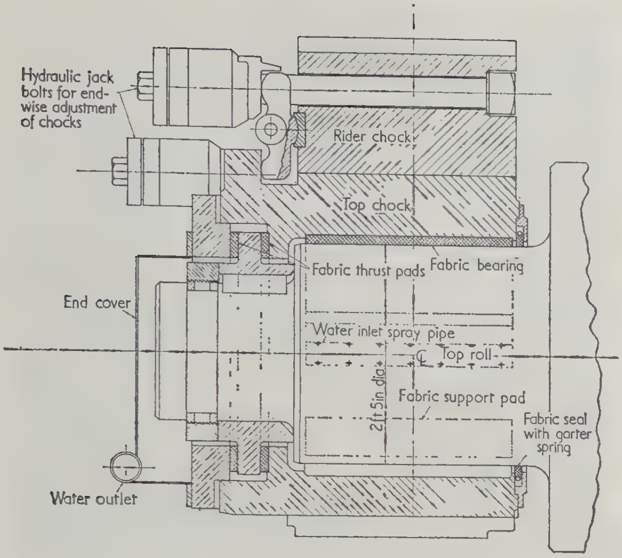
This mill, shown in Fig.3, has rolls of a maximum diameter of 52in and a barrel length of 112in. Its main purpose is to roll shaped blooms for all the universal beams, each of which has its own bloom shape designed to give, as early as possible, the correct relation between the volumes of metal in flange and web. It also rolls rectangular blooms for BS sections, and in order to make the mill as flexible as possible, it has been designed with a high lift to enable it to roll slabs up to 50in wide.

The drive to the mill is by twin motors, each of 4000 hp at 0–40–90 rev/min. The maximum operating torque of the two motors is 2650000 lb ft up to the base speed. The housings have a minimum post area of 700in^2 designed for a separating force on the rolls of 2700 tons.

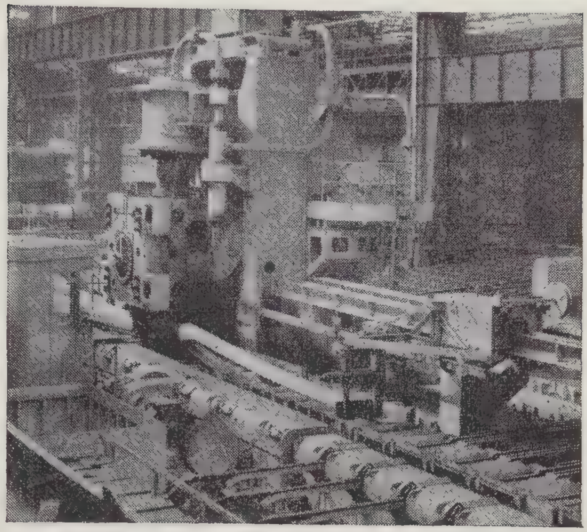
The rolls are carried in totally enclosed, resin-bonded fabric bearings, lubricated by automatically pumped grease and a continuous water flow. The endwise locating of the roll is at the undriven end only, by means of a collar on the roll neck which fits between two fabric pads in the chock, as shown in Fig.4.



3 *Blooming mill. The overhead walkway, running the full length of the mill, is in the background*



4 *Section through blooming mill roll chock showing endwise location*



5 *Bloom shear and measuring gauge*

Adjustment of the running clearance is made while the rolls are being assembled in the chocks, by fitting shims behind the fabric pad clamping ring. Endwise adjustment for matching the rolls is done entirely on the undriven side top chock, which is supported by a rider chock guided in the housing window, but without endwise adjustment. The top chock can be moved relative to the rider by three hydraulic jack bolts, two of which push the chock inwards, taking with it the top roll, while the third pulls the chock outwards. Locking nuts prevent any creep after the correct position has been reached.

The main screws, 18in dia., are driven by two 150–300 hp motors, Ward-Leonard controlled to give a screwing speed of 150–300in/min. Indication is by Selsyn to a dial in the pulpit, but there is also a mechanical indicator at the top of each screw showing fractions of an inch. A hydraulically operated screw relieving gear turns the first motion shaft of the screw drive, to free the screws if they have accidentally been run together. The mill spindles are 23in dia. and 32 ft 9in long. Lubrication of the universal joints, always a difficult problem, has been achieved by completely enclosing the joints at the motor end, and lubricating with oil sprays. At the mill end, grease is fed from a mechanical pump on the floor, through one of the support bearings and along the spindle to the slipper faces. The bearing has been fitted with seals to make it capable of transmitting the pressure of the grease.

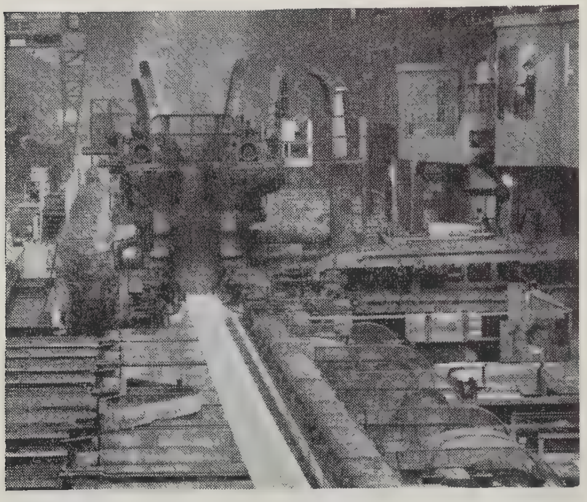
The manipulators have side guards of welded plate construction 25 ft long. The traversing rams are supported on slippers which are placed outside the width of the rollers, and away from the path of falling scale. The bloom tilting gear has been designed to prevent damage to the machinery when the fingers are brought down on top of a bloom. The floor-mounted tilting motor and reduction gear lift a narrow table on which runs a roller, mounted on a lever on the manipulator guard, and connected by links to the shaft and arms carrying the tilting fingers. The fingers lift when the table rises, but if they fail to come down the table falls away from the roller.

The main roller tables each comprise 14 rollers of solid, forged steel, 20in dia., spaced at 29-in centres. The two housing rollers at each side of the mill are direct driven from slow-speed motors, and the next four at each side, which take the heavy shock loads from the ingots while they are still short, are driven independently of the remaining rollers. Because of the difficulties which have been experienced with bearing cap bolts in main roller tables, on these frames the seatings for the cartridges in which the bearings are fitted are bored from the solid.

Because each universal beam section requires its own bloom shape, roll changing is much more frequent than in the usual blooming mill. The mill design, therefore, incorporates a duplex roll-changing rig on the offside of the mill, to enable a pair of rolls to be changed in less than 30 min. A transversely sliding carriage, capable of carrying two complete assemblies of rolls and chocks, stands alongside the mill, and before a roll change, a pair of new rolls is placed on the carriage. At the roll change, the old rolls are pulled out on to the carriage, which is then traversed to bring the new rolls in line with the mill axis. They are then pushed into place. The whole operation is under the control of one man at a control desk. The difficult task of engaging the roll ends in the driving spindles has been simplified by placing an auxiliary control station on the drive side mill housing, close to the point of engagement of roll and spindle. An operator at this point can take over control, and, as he allows the roll change sledge to creep inwards, he can inch each spindle up and down, turning the main driving motors if necessary, until engagement has begun.

Bloom and slab shear

The bloom and slab shear, shown in Fig.5, is an open-sided, up-cutting machine of 1350 tons capacity, hydraulically operated, and can cut slabs 10in thick and 50in wide, or equivalent areas up to 19½in thick. As the shaped blooms must, to avoid distortion of the ends, be cut in shaped blades, particular attention has been paid to rapid blade changing. Each blade can be released by first slackening five nuts, and then removing the blade on a special porter bar hung on the crane hook. The shaped blooms must be carefully guided



6 *Universal roughing mill, ingoing side*

7 *Universal finishing mill*

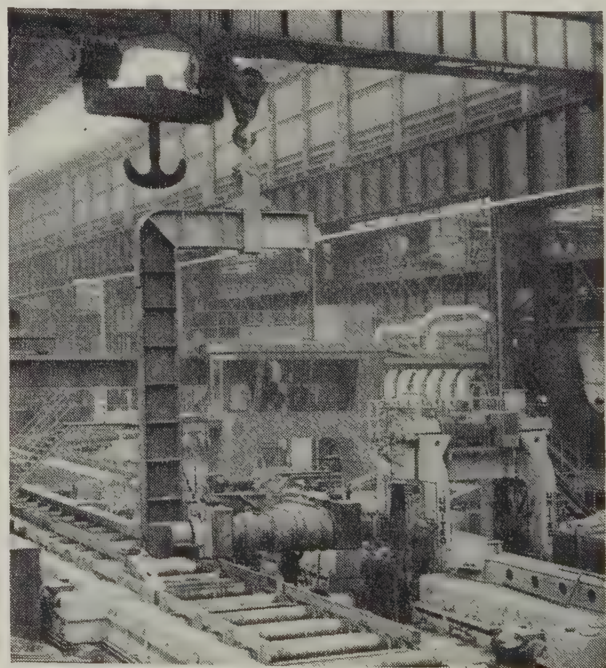
into position on the blades and, therefore, at the entry side of the shear, motorized side guides are fitted, the position of which is indicated to the operator by a pointer on a dial driven from the guide motor by a synchronous tie motor. There are two crop chutes, one at each side of the shear. The front crop is pushed forward by the bloom to a point where a hinged roller can be lowered to allow the crop to fall. The back crop is pushed backward, by reversing the bloom, to a gap in the ingoing table.

In pursuance of the company's policy of making the whole mill as flexible as possible with regard to its products, the blooming mill can roll shaped blooms, rectangular blooms, and slabs. Following the bloom shear, therefore, there are several routes which can be taken by the steel, depending upon its subsequent purpose. Shaped blooms for the largest of the universal beams, where the heat content relative to the radiating surface is sufficient to allow of the blooms being rolled into finished beams without reheating, travel direct from the shear to the universal roughing mill. Smaller shaped blooms are diverted to the continuous reheating furnace, of 80 tons/h capacity, and are then lifted over to the universal roughing mill approach table by a special overhead travelling crane, controlled from the operator's pulpit at the breakdown mill. When the crane is set in motion, it picks up a bloom which has been discharged from the furnace, carries it over to the roller table and holds it suspended. The operation of a second switch lowers the bloom and, when it has travelled clear of the hooks, a photocell initiates the return journey of the crane to its waiting position at the furnace.

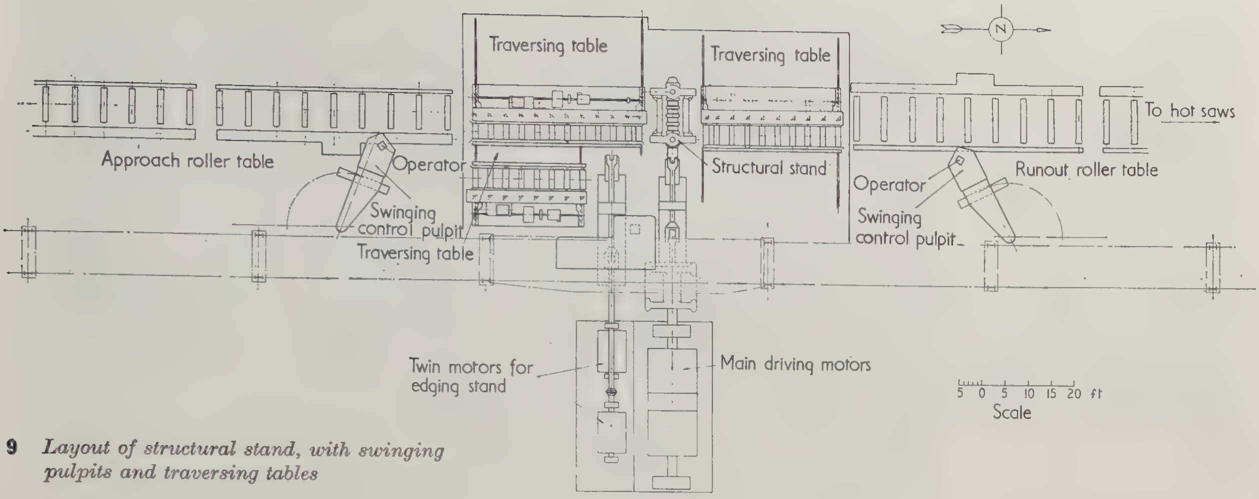
Rectangular blooms may go direct from the shear to the breakdown mill for the first stage of their reduction to BS structural sections or to billets, or alternatively, they may be first put through the reheating furnace. Blooms and slabs for other of the company's mills are allowed to cool on the bank, and are then lifted off by crane.

Universal mills

The two universal mills, roughing and finishing, (Figs.6 and 7) each comprise two stands placed in tandem, the edging stand with its two horizontal rolls coming first, followed at a distance of 13 ft by the main stand with two horizontal and two undriven vertical rolls. The main rolls, 53in dia. when new, have a plain barrel of a width to suit the distance inside the flanges of the beam. They are carried in fabric bearings, lubricated by water sprays and by grease. Because the chocks of the vertical rolls must be placed between the necks of the horizontal rolls, the main roll bearings cannot be totally enclosed as on all the other stands. In this type of mill, where the flange edges are not controlled in the main stand, successful rolling is largely dependent upon maintaining the rolled bar at the correct level, and on the main stand, therefore, top and bottom screws are fitted which bring the rolls together between passes while maintaining a constant



8 *Breakdown mill roll being changed*



9 *Layout of structural stand, with swinging pulpits and traversing tables*

pass level. The vertical rolls run on roller bearings on fixed spindles, and each roll is pushed inwards between passes by two screws housed in a yoke cast integral with the main housing between the horizontal roll necks. To prevent backlash, the vertical rolls are held against the screws by short side guides, pulled back by hydraulic cylinders.

The mill driving-spindles are retractable and, as each spindle is pulled back at a roll change, it brings with it the roll end coupling box which is held supported on the spindle cradle in the correct position for re-engagement with the new roll. The main rolls are driven through pinions from a twin-armature motor of 8000 hp, running at 0–65–165 rev/min. The maximum operating torque is 1615000 lb ft up to the base speed.

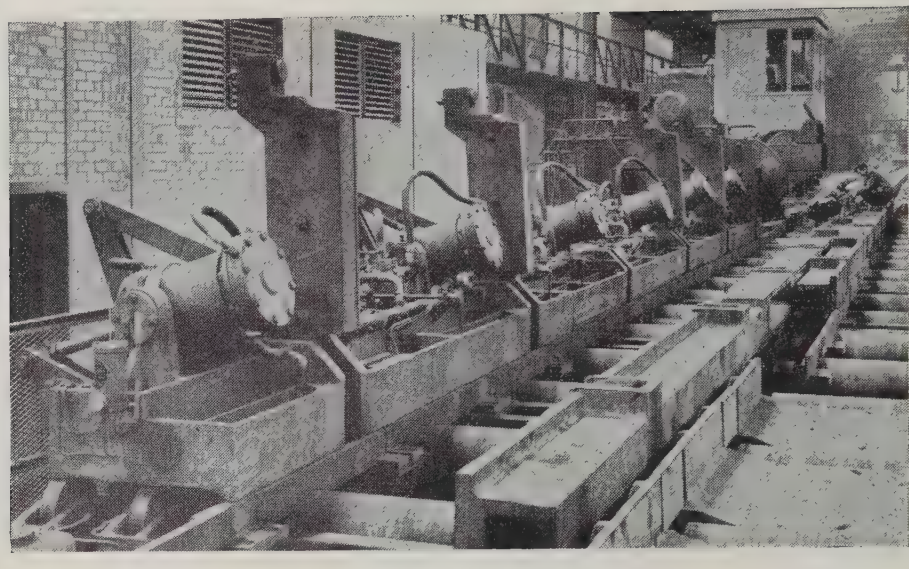
The edging stand has two 43in dia. rolls, running in totally enclosed fabric bearings. As in the blooming mill, any axial thrust from the roll is taken by two fabric pads enclosed within the chock. Adjustment of the running clearance can be made at any time during rolling by a large thrust screw in the end cover of the chock. The drive is from twin motors, each of 1350 hp at 0–125–310 rev/min with a maximum operating torque of 285000 lb ft.

One novel feature of these mills, both roughing and finishing, is the arrangement of the side guides and their adjustment relative to the positions of the rolls. The four rolls in the main stand, and the two in the edging stand, must all be brought closer together between passes by an amount which will give the correct reduction to all parts of the beam, at the same time controlling the flange width and keeping the web central. Equally important is the accurate guiding of the beam on to the rolls, and to do this, mechanical side guides are fitted. In addition to the guides for the vertical rolls, which are pulled back against them by hydraulic pressure, long guides run between the edging rolls from the entry side, almost up to the vertical rolls. These guides are moved by screws driven from a motor which is synchronized with the motor driving the vertical roll screws. Four dials indicate to the mill driver the positions of the three pairs of rolls and the guides. In addition, the two mills have automatic presetting equipment for the positions of all the rolls, so that the driver can, by pressing a single button, give the correct drafting for flange and web thicknesses and flange length, for each successive pass. The presetting equipment also governs the correct matching of the speeds of the two pairs of rolls, main and edging, in both directions, so that there is always a slight tension in the beam.

At the two sides of each mill are short roller tables mounted on carriages which can be traversed accurately to align each table with the mill centre line. These tables have adjustable side guards and a height adjustment to suit the mill pass line. For roll changing, the traversing tables are moved out of the way, and the roll stands are lifted out, after disconnecting all the pipes and electric cables, by two overhead cranes of 275 and 180 tons capacity. Previous to a roll change, spare stands are set up complete with rolls and guides on dummy beds, ready to be carried over to the mill immediately after the old stands have been taken away.

In order to roll BS sections, the two universal mills are replaced by structural stands, and the breakdown mill is called in as the primary roughing stand of a three-stand mill. This breakdown mill has rolls 40in dia., 96in long, driven from a single motor, similar to the motors driving the main universal stands. The mill has sideguard manipulators with tilting fingers on both sides of the mill, and a Friemel turner for small blooms on the ingoing side. Roll changing in this mill is by the C-hook shown in Fig.8, lifting each roll in turn.

The conversion of the universal mill to a structural mill is made by removing the main and edging stands, replacing them by a structural stand on the bed vacated by the main stand. The ingoing traversing table which served the universal mill is replaced by a longer table, covering the gap left by the edging stand. When the structural stands are in use, the travelling tables act as manipulators to move the bar from one groove to the next. When rolling structurals, control of the mill is from swinging pulpits, as shown in Fig.9. These stand on a structure, one end of which is pivoted to the overhead walkway gallery, while the other runs on a curved track on the floor, so that the pulpit can be swung out over the roller table when structural sections are being rolled.



10 *Hot saw measuring carriage*

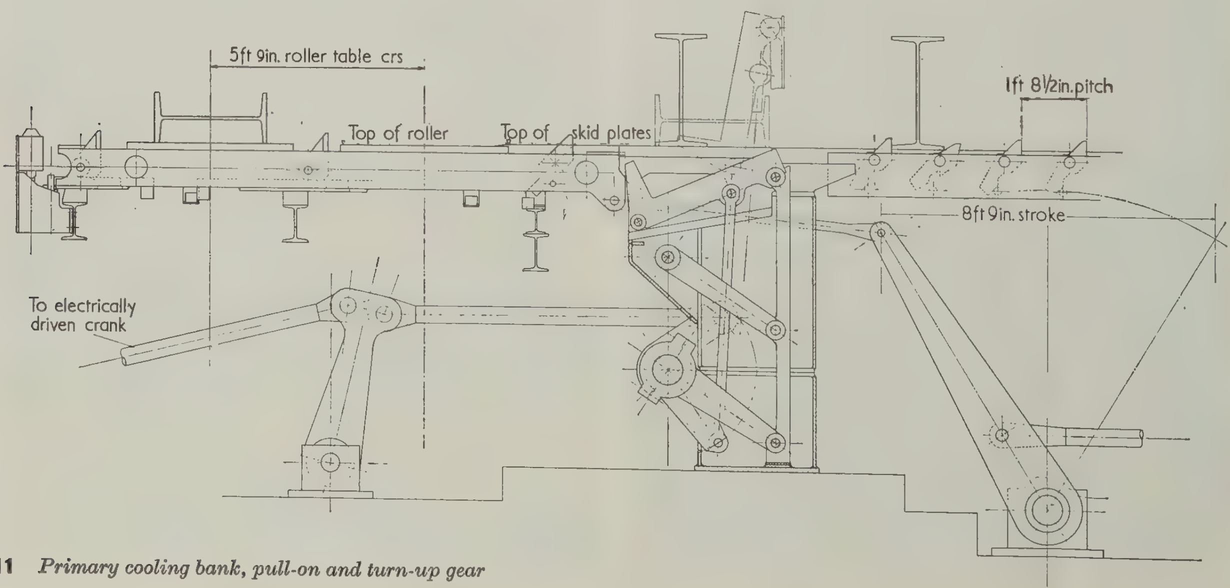
Hot sawing

The finished rolled bar can be directed by hydraulically operated sweeps into either of twin roller tables leading to the two hot saws. The measuring gear is novel, designed to cope with the problem of cutting every bar to the length ordered by the customer, at the same time keeping pace with a mill production which can be over 200 tons/h. At each saw a sliding carriage, shown in Fig.10, carries six air-operated stoppers, spaced at a nominal 10 ft centre distance. The carriage can be moved any distance up to 10 ft, so that by moving the carriage and selecting a stopper, any length between 10 ft and 70 ft can be measured. Carriage movement and stopper selection are both controlled from a set of push-buttons in the operator's pulpit, the carriage actually moving to its next position while the preceding bar is being cut.

The carriage is moved by a hydraulic cylinder fed from a swash-plate pump. The appropriate length up to 9 ft 11in having been selected, the operator starts a pilot motor which, through a differential gear, inclines the swash-plate, so feeding oil to the cylinder. As the carriage moves, its movement is fed back to the differential, and when the pilot motor, having turned according to the length selected, stops, the feed-back returns the swash-plate to its neutral position and the carriage stops. When the stopper selected for the tens of feet is dropped, the selection is locked and the operator can make his next selection. When the stopper is lifted, the previous selection is cancelled and the carriage immediately moves to its new position. A further refinement is a second pilot motor governing the contraction allowance. If a bar being sawn is seen to be hotter or colder than normal, the contraction pilot motor can be rotated to adjust for the variation from the usual temperature.

Cooling banks

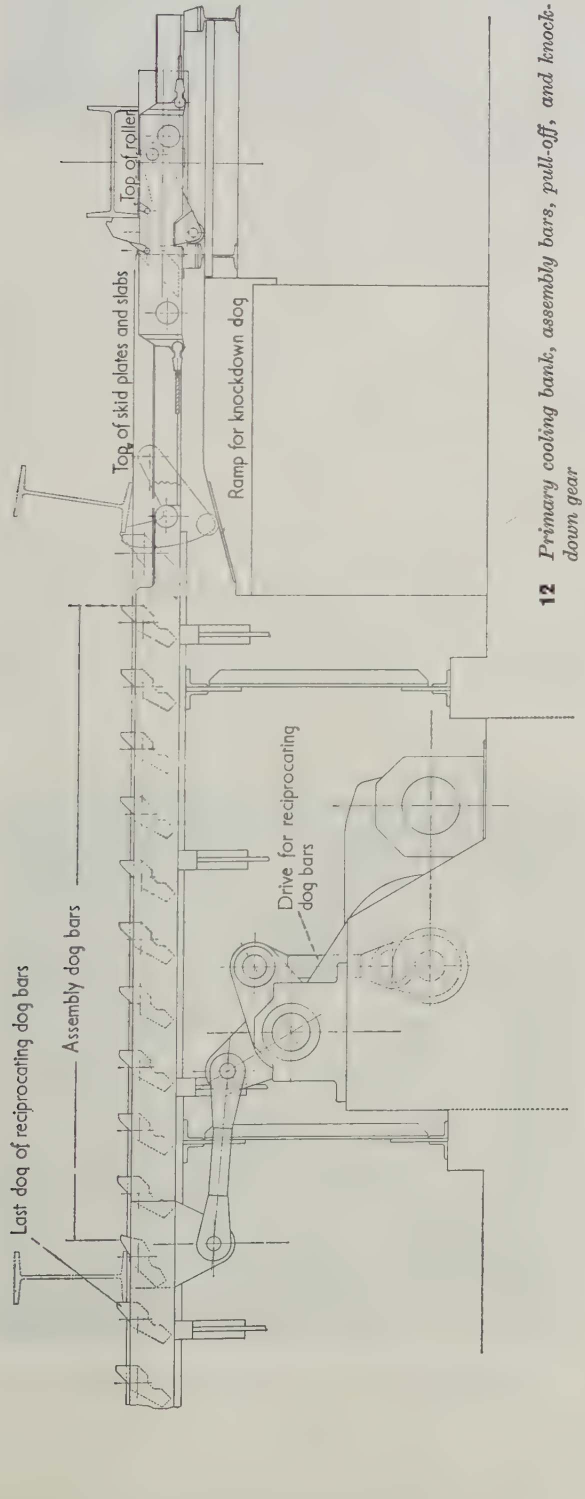
The practice of cutting customers' lengths at the hot saws has always entailed much wasteful work in the



11 *Primary cooling bank, pull-on and turn-up gear*

subsequent sorting of the bars. In order to obtain the maximum yield of saleable steel from the rolled bar, the sawmen cannot cut in the succession shown on his order sheet, and therefore, on the cooling bank will be found at any one time, bars from several orders all mixed together. At Lackenby, an unusual cooling bank arrangement has been installed to overcome this difficulty. Instead of the usual set of banks all accepting hot bars on one side and delivering cold bars at the other, these are arranged in tandem. The two primary banks deliver half-cooled bars to the final banks, which feed cold bars to the straighteners. Between the primary and the final banks there is an opportunity of sorting the bars, so reducing the work of handling by overhead crane at a later stage. In the following description of the details of the banks, it will be noted that there are, in both sets of banks, several pieces of overlapping equipment. The object of this overlapping is to create buffer stocks, thus divorcing from each other the three major operations: sawing, sorting between primary and final banks, and straightening. This is essential with high production rates, to prevent short-term stoppages in the final processes causing a mill stoppage.

13 *Primary cooling bank; a beam being turned up on to its flanges*

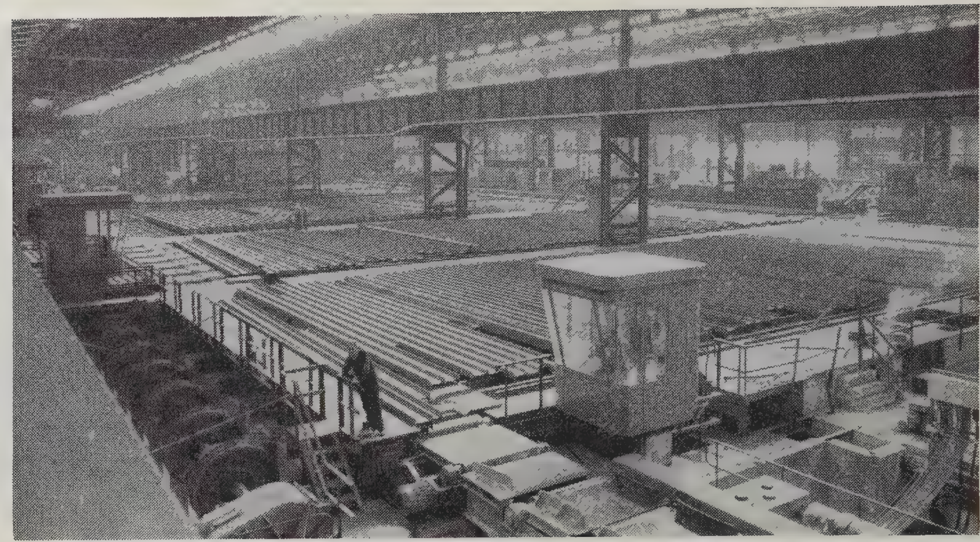


12 *Primary cooling bank, assembly bars, pull-off, and knock-down gear*

There are two primary banks, each 90 ft wide; one is 121 ft between centres of roller tables, the other is 127 ft. Disappearing stops at the centre of each bank allow two short bars to be placed end to end. The cooling bank supports are chevron-jointed cast iron segments, 2 ft long, bolted to joists. The various bank mechanisms are shown in Figs.11 and 12. The rolled bars are swept off the saw runout table by the pull-on gear, which has a set of dogs, ambushed on the return stroke, to clear the roller table, and a second set of pivoted dogs to move the bar after it has been turned up on to one of its flanges by the turn-up gear. The second stroke of the pull-on gear clears the bar from the turn-up mechanism, and brings it within reach of the reciprocating dog bars, which have a series of pivoted dogs, moving with a stroke of 24in, so that all the beams are moved one space across the bank each time a new beam arrives. The primary banks are shown in Fig.13.

At the cold side of the bank a set of 11 assembly bars, also with pivoted dogs, but rope-hauled, can take any number of rolled bars up to 11 out of the control of the main dog bars, and into the range of the next piece of equipment which pulls the rolled bars one by one on to the cold side roller table, throwing each beam down as it is moved.

The runout table from the primary banks is common to both, and continues as the run-in table for the four final banks. Along this table every bar passes a control point, where its code number is recognized, so that it can be directed to one or other of the final banks, to join the bulk of the bars of the order to which it belongs. Three of the final cooling banks are



14 *General view of final cooling banks*

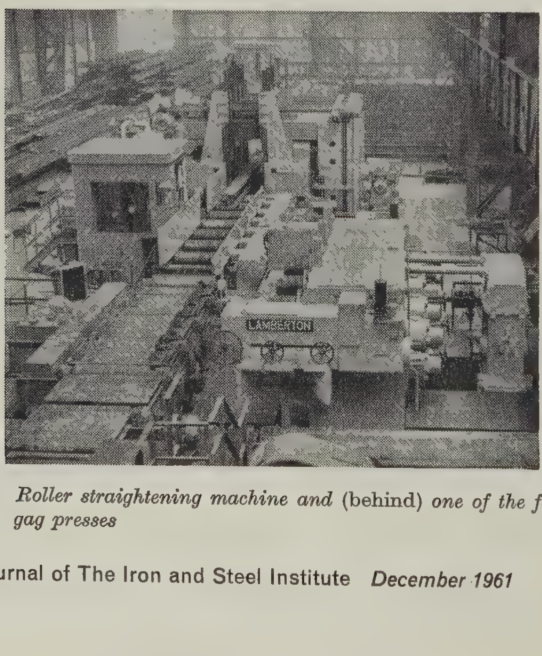
60 ft wide, the fourth 90 ft (Fig.14). The rolled bars from the run-in table are swept on to the bank by the pull-on gear, similar to that on the primary banks, except that the single finger is solenoid operated and can push in either direction. The rolled bars are next handled by a set of rope-hauled skid bogies, which brings them within the range of the main traversing mechanism. This comprises a set of dog bars, each with 12 pivoted dogs at 8 ft centres, reciprocated by levers on a massive fabricated beam which is rocked by hydraulic power. This mechanism can move a load of 500–600 tons. A further set of rope-hauled skid bogies can take the rolled bars and place them one by one on the roller tables leading to the straightening machines.

Straightening

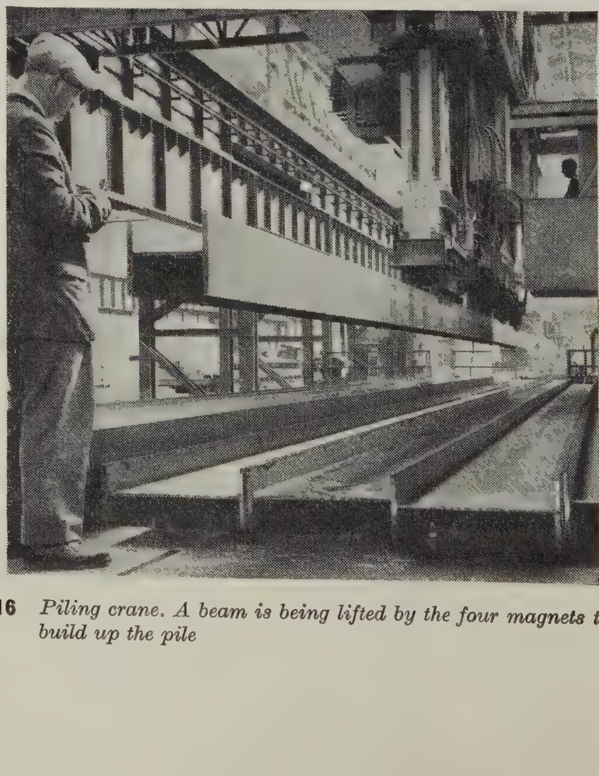
There are four reciprocating gag presses for the largest beams, and one roller straightening machine for the smaller universal beams and for other sections. This machine, with a gag press behind, is shown on Fig.15. On the gag presses, both heads have a centre anvil and six posts, all of which can be raised by electric power, so that bends in either direction can be removed without turning the beam over. The very simple manipulator comprises two massive vertical pegs, one on each side of the machine, which can be pushed up to raise a beam on to one flange, or to throw it down. The roller straightening machine is mounted on a traversing carriage, so that it can be by-passed when it is not required.

Piling and loading

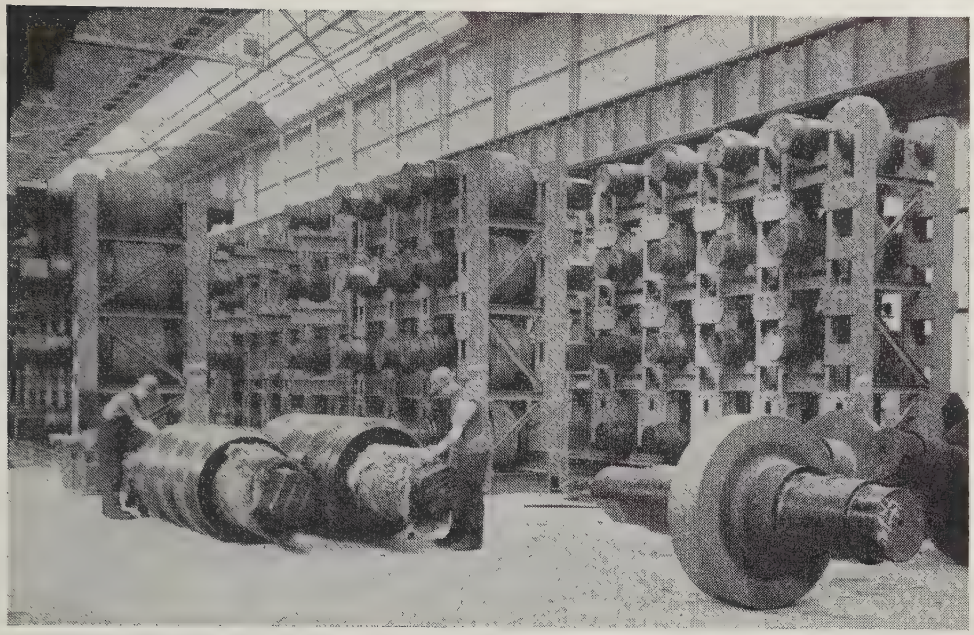
From the straightening machines, the bars are skidded to short banks in the piling bay. Here are the piling cranes, one of which is shown in Fig.16. These are specially designed for nesting universal beams into neat piles suitable for loading into wagons. Each crane carries, rigidly suspended from the crab, a beam on which are four vertical rams, actuated by rack and



15 *Roller straightening machine and* (behind) *one of the four gag presses*



16 *Piling crane. A beam is being lifted by the four magnets to build up the pile*



17 *Part of the roll stocking racks. Rolls are kept in these racks, in sets of four, when not in use*

pinion, motor driven and carrying bi-polar magnets. The piles of beams are built up on self-propelled transfer cars, which can travel into the adjacent loading bay. The 15-ton overhead cranes, each equipped with a load beam carrying five hooks, lift the piles into wagons on double rail tracks running the length of the bay. In addition, side loading fork lift trucks, of 30000 lb capacity, can take piles of beams from the transfer cars and place them on the floor.

Partly in the loading bay, and partly in the piling bay, is the cold sawing and beam slitting plant. At the saws, the measuring of the length of the bar is automatic. The bar which is to be sawn pushes along a light carriage, to which is attached the measuring tape. As the tape unwinds, the approximate distance moved is shown on a large dial, and the exact distance by a magnified image of the tape on a screen.

Water system

Filtered water is required for the roll necks and barrels, and for the air filtration systems in the motor houses, and unfiltered water is required for flushing mill scale. The district mains water supply is used for make-up only. The water supply to the motor houses is a closed system operated in series with the water-cooled skids at the reheating furnace, and has its own cooling tower. All the filtered water used on the roll necks and barrels falls into the scale flumes, and has to be re-filtered. Scale is collected in three scale pits, two of them decanting into the blooming mill scale pit, where three return pumps send the water to the main settling ponds. The two ponds, with an area of 8300 ft^2 allow fine scale to settle and have provision for skimming oil. Scale flushing water is pumped direct from the ponds back to the mill, and water for filtering is pumped into six 35-ft dia. tanks containing a layer of wood wool. The filtered water is pumped back to the mill at a pressure of 50 lb/in^2, and to ensure continuity of supply to the roll neck bearings, two elevated pressure tanks have been installed, with sufficient capacity to allow the mill to be cleared if all the pumps fail. The quantity of water pumped by the scale pit pumps is about 13000 gal/min, of which 5000 gal is filtered water, 2500 gal is the continuous flush at the blooming mill, and the remainder represents flushing at the universal and breakdown mills.

PART 2 ELECTRICAL FEATURES

SYNOPSIS

Part 2 of the paper describes the electrical supply, distribution, and protection provided for the mills and gives a description of the following: main drive motors and control for the blooming, beam roughing, and beam finishing mills; operation of the beam roughing and finishing mill automatic preset controls; Ward-Leonard mill auxiliary drives, control, and standby interconnexions; crane controls and supply; hot saw motors; plant lighting; communications; cabling. 1940B

THE MAIN ELECTRICAL power supply for the Lackenby works is carried by six 11-kV feeders direct from the North Eastern Electricity Board 66-kV substation at Grangetown. This is the supply point for the three works, Cleveland, Lackenby, and Redcar which are all interconnected at this point as shown in Fig.1. The service capacity at the Grangetown substation is 45 MVA and this is provided by four 15 MVA 66/11 kV transformers. Additional power is obtained from generation at each of the three works and amounts to an average of 38 MW while the combined load of the three works is about 60 MW of which 20 MW is required at Lackenby, the blooming, the universal beam roughing and finishing mills taking 16 MW of this. By having the three works interconnected the best use can be made of the generation at any works and so reduce the amount and cost of imported power.

The distribution in the Lackenby works is at 11 kV, 2·75 kV, 440 V, three-phase ac and 230 V two-wire dc and locally at 110 V ac for portable tools and hand lamps.

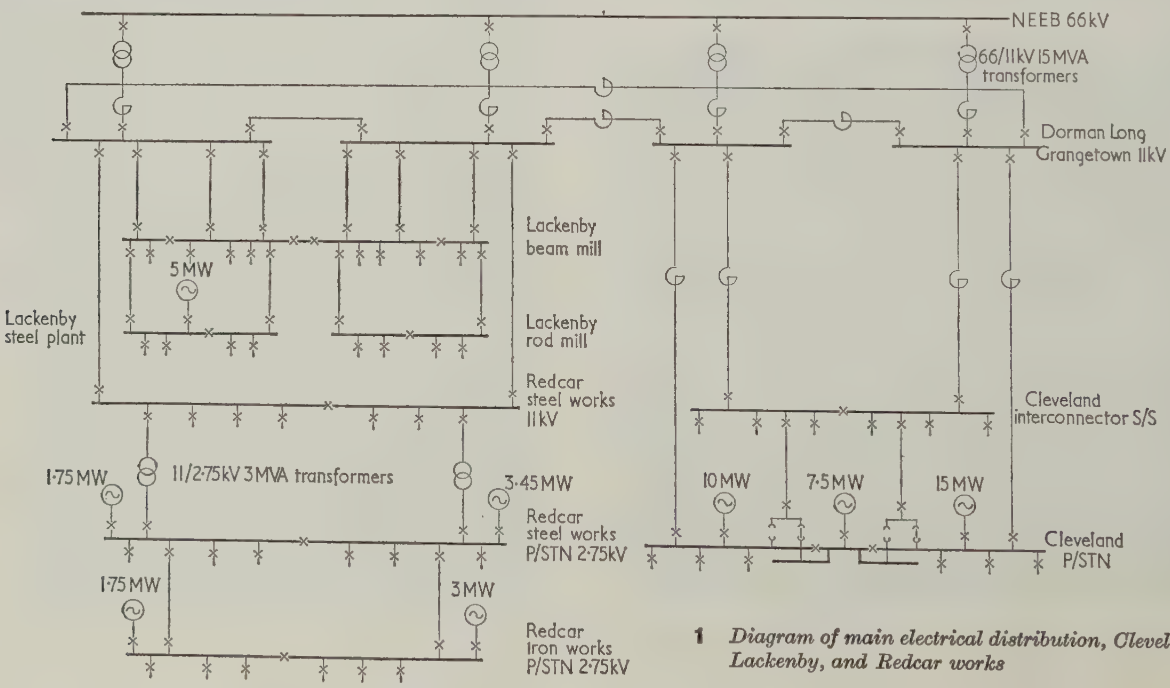
There are three 11-kV switchboards in the works: one at the South motor house where the six 11-kV feeders from Grangetown terminate; this board feeds the other two 11-kV boards, one at the rod mill motor house and the other at the steelplant power station. All this switchgear has a fault rating of 350 MVA.

The largest units of electrical plant are supplied at 11 kV, motors between 100 and 1000 hp at 2·75 kV, and constant speed motors of less than 100 hp at 440 V. The variable speed drives for cranes and mill auxiliaries are dc, either Ward-Leonard with standard 230-V mill motors on variable voltage up to 460 V or by standard mill motors supplied from the 230 V constant voltage dc with resistance-type speed control. The Ward-Leonard control is used where very quick speed response is required for the operation of screwdowns, manipulators, and mill front and back tables.

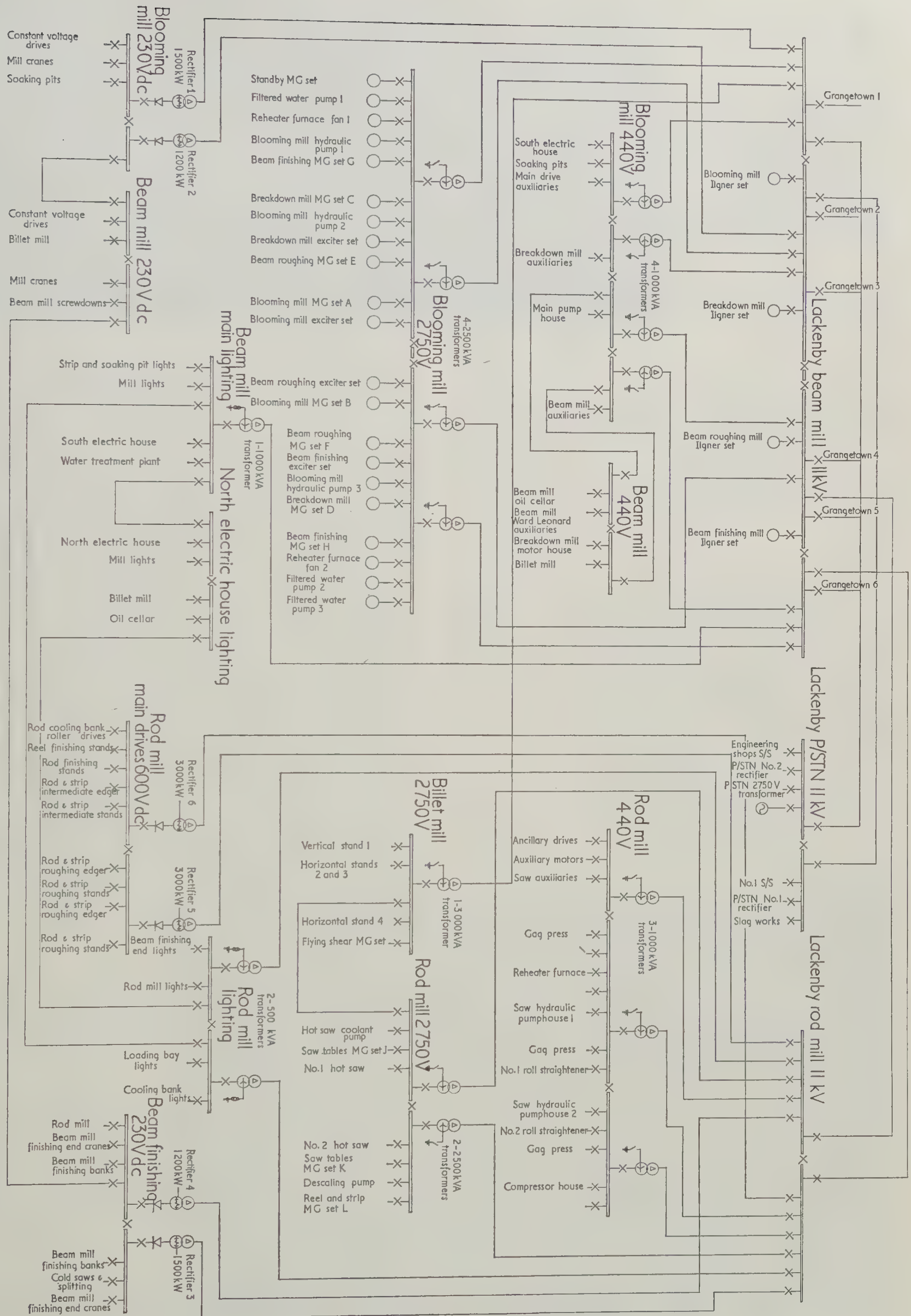
Throughout the distribution at 11 kV, 2·75 kV, and 440 V, section switches have been provided to divide the loads between the transformers and to enable the essential loads to be fed from separate sources; the essential loads usually being water pumps in groups of at least two. The schematic diagram for the plant is shown in Fig.2.

The control, indication, metering, and protective gear associated with the 11-kV and 2·75-kV switchboards are all contained in a continuously manned control room on the first floor of the annexe to the South motor house (*see* Fig.3). The control board is of the cubicle type arranged with the 11-kV and 2·75-kV controls on either side of a central group of instruments, meters, and alarm equipment.

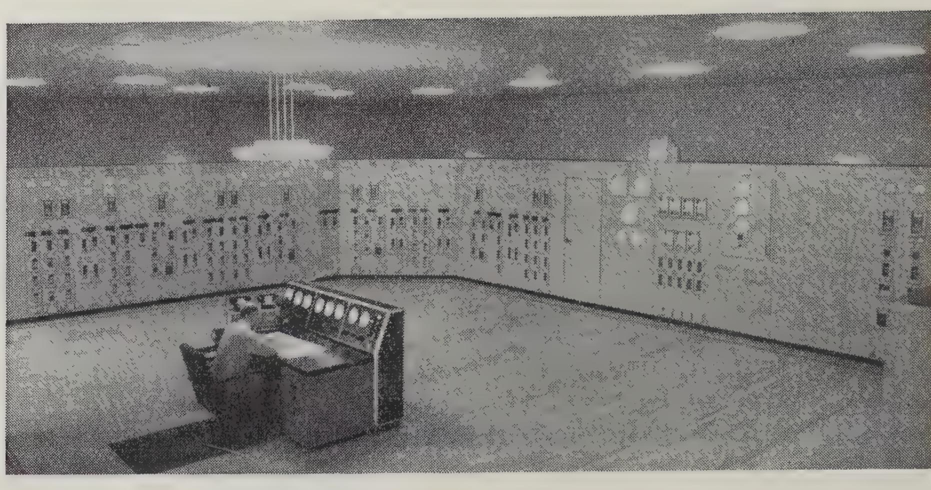
All plain feeders, busbar sections, transformer, rectifier feeder switches, and the steelplant 5-MW alternator are under the full control of the operator in this room. The motor feeders supplied from the 11- and 2·75-kV switchboards are treated in a different manner. Individual control stations are provided adjacent



1 *Diagram of main electrical distribution, Cleveland, Lackenby, and Redcar works*



2 *Diagram of electrical distribution system*



3 *Control room at the South electric house*

to each motor so that the motor attendant can stop and restart his motors as he wishes, while the control room operator can only stop and prevent a motor from restarting. For the larger drives in the mills where the power demand has a significant effect on the loading of the whole system the motor attendant must seek permission to start from the control room operator and he is prevented from starting until this permission is granted.

Protection is provided on the switchgear as listed in Table I.

For the mills there are three large motor houses and a small one for the billet mill (*see* Fig.4). The two main ones are the North and South motor houses which lie along the east side of the main mill bay. The South motor house has brick-built walls with a flat-decked roof and is 282 ft long with an overhead crane span of 60 ft with a 60-ton crane. At its south end are the twin motors which drive the blooming mill and adjacent are the Ilgner set and its accompanying exciters (Fig.5). The central portion of the house is occupied by four motor-generator sets for the Ward-Leonard controlled mill auxiliary drives. At the north end of the building is the Ilgner set and its exciters for the breakdown mill and steel-tank mercury arc rectifiers for the constant voltage dc supplies.

An annexe on the east side of the South motor house contains 11-kV, 2·75-kV, and 440-V switchgear, the electrical control room, and the air filtration plant with outside transformer bays ranged along the wall. The North motor house is similar but has no annexe and contains the main and edger drive motors, and Ilgner sets and controls for the universal beam roughing and finishing mills, and the Ward-Leonard MG sets for their auxiliaries. Both the North and South motor houses have basements containing auxiliary gear for the Ilgner and Ward-Leonard sets and all the main cable work. These basements act as ducts for the filtered air.

The other large motor house, which is also a brick building, contains all the main drives for the rod mill, Ward-Leonard MG sets for the auxiliaries at the beam mill hot saws, and a main transformer, switchgear, and rectifier substation for the northern end of the mill buildings, and like the North and South electric houses it has an air filtering system supplying cooling air to the machines via basement ducts.

In each of the large motor houses air is drawn into the building through two banks of oil-film type filters, each bank having a capacity of 160000 ft^3/min and for each filter bank there are four 50000 ft^3/min fans, three running and one standby. This filtered air is delivered to the motor house basement and from there 32000 ft^3/min is blown through the blooming mill main drive motors, 24600 ft^3/min is blown through those Ward-Leonard controlled mill auxiliary motors adjacent to the blooming mill stand, some through a 7350 ft^3/min electrostatic filter to make up the air in the Ilgner set recirculating system, where 70000 ft^3/min is recirculated and 5600 ft^3/min is lost via the generator commutator extraction fans.

Air also passes into the motor room through the Ward-Leonard MG sets and the rectifier cubicles and is then exhausted via adjustable louvres high up in the end walls of the motor room. The ventilation system for the South motor house is shown diagrammatically, in Fig.6, and is typical for the north and the rod mill motor houses.

Where mill auxiliary motors have an almost continuous duty, 1-h rated motors are used and are supplied with filtered cooling air taken from the basements of the motor houses and boosted by fans through ducts in the foundations to the motors, entering through the motor bedplates and exhausting into the mill through louvred covers on the motors. The average quantity of air allowed per motor is 1300 ft^3/min for 150 hp motors and 1000 ft^3/min for 100 and 75 hp motors.

Main drives

The 50in blooming mill is driven by twin motors each of 4000 hp rms, 1000 V$\pm$0–40–90 rev/min, the combined drive having an rms torque of $1{\cdot}06\times10^6$ lb ft with a working peak of $2\frac{1}{2}$ times this and a cutout torque of 3 times (*see* Fig.7).

The Ilgner set motor has a 6000-hp 11-kV motor with slip regulator, driving four 1600-kW 500-V generators and a 200000 hp/s flywheel at a nominal synchronous speed of 600 rev/min. The main drive motors for the beam roughing and beam finishing mills (Fig.8) are alike and interchangeable. Each drive is by two motors built into one frame driving a single shaft, the two armatures are bolted together in the centre, and the commutators are at either end. Each motor in this unit is rated at 4000 hp rms 400 V$\pm$ 0–65–160 rev/min giving a combined drive rms torque of $0{\cdot}65\times10^6$ lb ft with a working peak of $2\frac{1}{2}$ times and a cutout torque of 3 times.

4 *View of South electric house with mill buildings behind, showing transformer bays along the front of the building*

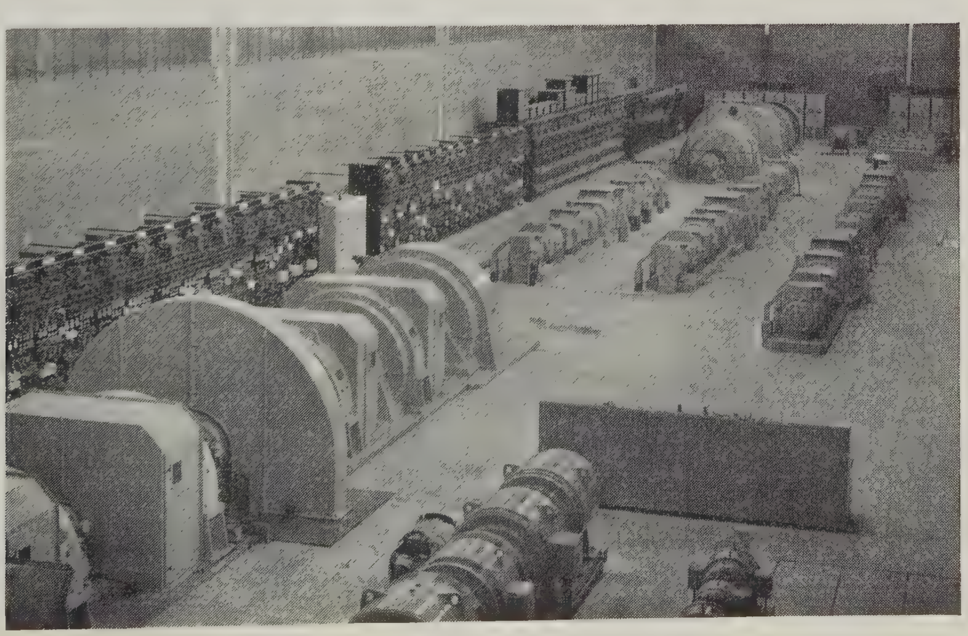
In addition to the 8000-hp unit driving the main rolls on the beam roughing and finishing mills there are edger drives which for each mill is a twin motor drive totalling 2700 hp rms, each motor being 1350 hp rms 800 V$\pm$0–125–310 rev/min and the combined rms torque of the edger drive per mill is $0{\cdot}114 \times 10^6$ lb ft with working peak and cutout torques of $2\frac{1}{2}$ times and 3 times the rms torque respectively.

The beam roughing and finishing mills 8000-hp units are supplied from separate Ilgner sets (shown in Fig.9) each having a 6000-hp rms 11-kV motor with a slip regulator driving four 2150-kW 800-V dc generators and a 200000 hp/s flywheel, three generators supply the 8000-hp motor and one supplies the twin drive edger motors.

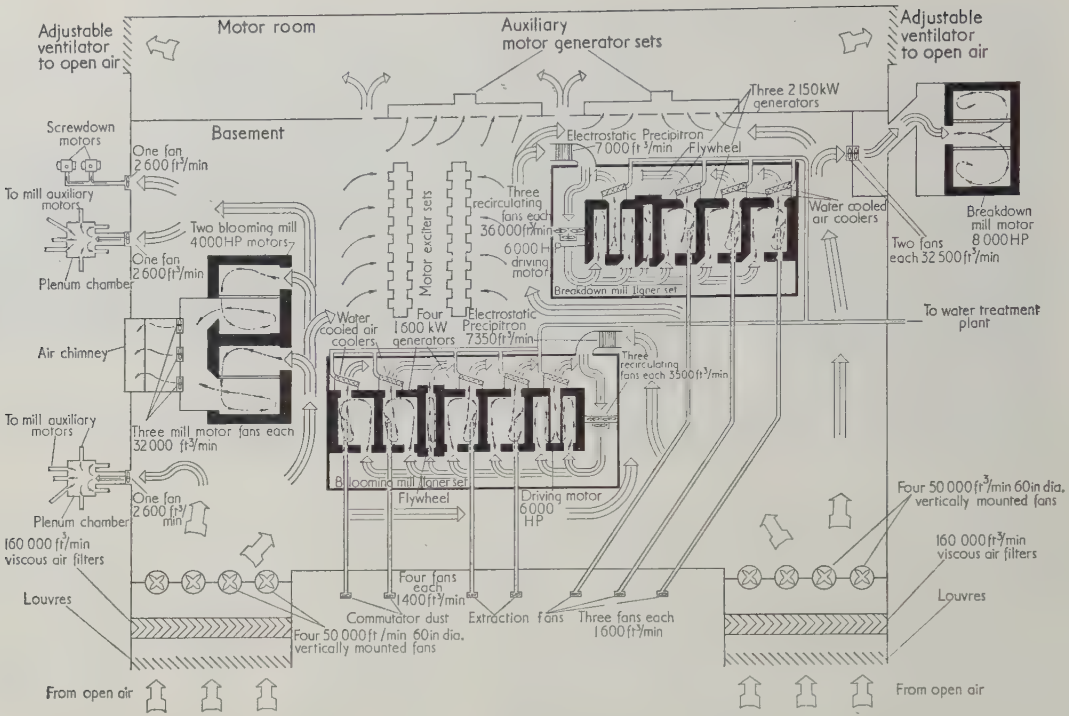
There is a control pulpit at each mill and the blooming mill has the usual manual controls using the BISRA-type master controllers for the screwdown setting and manipulators. On the beam roughing and finishing mills there are more adjustments to be made for each pass, namely screwdown, vertical roll, edger roll screwdown, sideguards setting, and speed matching between the edger and the main rolls. This is all done for the mill driver by the push of a button at each pass change, and is achieved by presetting the positions for each pass on a slider board shown in Fig.10. The positioning of the sliders is facilitated by graduated scales and determines the controlled setting for a particular motion and pass. The slider boards can cater for 19 passes and two sets of slider boards are fitted in the control pulpit at each mill, so that while one set is in use for rolling the other can be set up for the next rolling programme.

TABLE I Details of protection provided on switchgear

Plant	Type of protection
Main feeders and interconnectors	Solkor and 3-pole IDMTL overcurrent directional or non-directional as required
Busbars beam mill 11 kV only	Leakage to frame, earth fault
Section switches	None
Transformers down to 500 kVA	Intertripping on all but last item (NI)
HV side	Instantaneous balanced earth fault IDMTL overcurrent, 3-phase Instantaneous high set overcurrent 2 ph
LV side	Instantaneous restricted earth fault IDMTL standby earth fault IDMTL overcurrent (NI)
Rectifier transformers	Instantaneous balanced earth fault Instantaneous high set overcurrent 2 ph IDMTL overcurrent 3-phase
Ilgner set motors	Thermal overcurrent and phase unbalance Instantaneous earth fault Instantaneous high set overcurrent 2 ph IDMTL under voltage DTL rèverse power, 3-phase
Motors	Thermal overcurrent and phase unbalance Instantaneous earth fault Instantaneous high set overcurrent, 2 ph IDMTL under voltage



5 *South electric house looking north with the blooming mill Ilgner set in the left foreground*



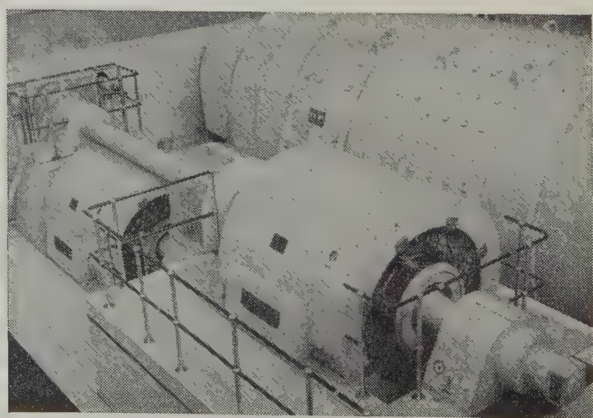
6 *Diagram of ventilation system*

In addition manual control is instantly available to the operator by means of a master switch which cuts out the automatic positioning control, but it remains coupled to the roll movements during the manual operation so that the operator can return to the preselected rolling schedule whenever he wishes. The positions of the mill variables, the screwdowns, vertical rolls, and sideguards are all indicated back to the master control gear by synchronous tie motors. When the pass initiating button is pressed, motors operate the various drives until the synchronous tie motors come into electrical alignment with the receivers in the control equipment already set up by the slider boards. An electronic balance anticipator is used in the control to slow down the motion as the rolls approach the preselected position; this helps to prevent overtravel and to give accurate positioning, if overtravel does occur then the motion is reversed until this is corrected. The use of this equipment results in faster and more accurate rolling and a much more regular product with less fatigue for the driver.

The location of the main drive control pulpits for the beam roughing and finishing mills is similar. When rolling universal beam sections a pulpit is used at the side of the mill stand and over the mill spindles, but when rolling standard joist sections two pulpits per mill are used, one on either side of the mill stand, and are placed so that the drivers can see the entry of the steel into the mill rolls. The latter pulpits are moveable and when not in use are parked out of the line of the mill so that there is no interference with the sighting of the mill from the universal beam mill pulpit.

The main drive control equipments incorporate Magamp and amplidyne controls for rapid response to the driver's control and the protective devices which provide motor current limit and generator current limit. If the motor and generator current limits cannot deal with an abnormal overload there is a motor overload relay which removes the excitation

7 *Blooming mill 4 000-hp main drive motors*



8 *Universal beam finishing mill main and edger drive motors*

9 *North electric house looking south*

from the motors and generators, and as a final safeguard for the motors and generators there is a circuit breaker.

On the universal beam roughing and finishing drives the control provides for the matching of the speeds of the edging and main motors. This matching must take into account the respective roll diameters and the direction of the steel through the mill. In one direction the edger rolls must have the same peripheral speed on

10 *Slider boards for the automatic preset control used on the universal beam roughing and finishing mills*

TABLE II Details of Ward-Leonard drive at blooming mill

	Motors, hp	Speeds, rev/min	Generators, kW	V
Approach roller table	1, 150/300	0–460–920	1, 240	0/460
Front mill table rollers 5–14	2, 75/150	0–515–1030	1, 240	0/460
Front mill table rollers 1–4	2, 75/150	0–515–1030	2, 120	0/460
Back mill table rollers 1–4	2, 75/150	0–515–1030	1, 240	0/460
Back mill table rollers 5–14	2, 75/150	0–515–1030	2, 120	0/460
Left-hand manipulator traverse	2, 150 in series	0–460	1, 240	0/460
Right-hand manipulator traverse	2, 150 in series	0–460	1, 240	0/460
Screwdown	2, 150/300	0–460–920	2, 240	0/460
Front breast rollers	2, 30/60	0–95–190	2, 52	0/100
Back breast rollers	2, 30/60	0–95–190	2, 52	0/100
Runout roller table	1, 150/300	0–460–920	1, 240	0/460

matched roll diameter as the main rolls and a slower speed in the other direction. In addition the control provides an adjustment of the edger twin drive to allow compensation for unmatched edger rolls, and the edger motors have an inherent drooping characteristic to make the matching of the edger and main rolls less critical. Adjustments for each pass are set up on the presetting equipment and are changed between passes by relays operating in the control scheme.

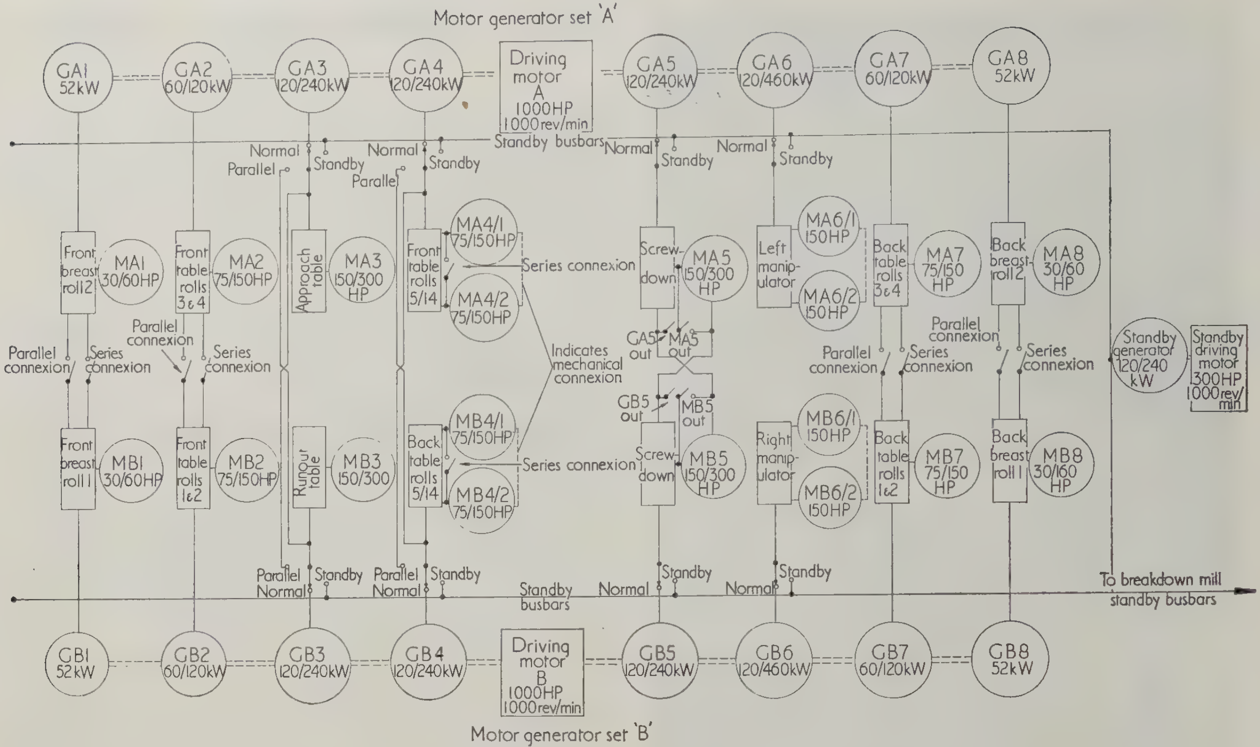
Ward-Leonard controlled auxiliary drives

To match the quick reversal times of the mills, the mill auxiliary drives adjacent to the stands are all Ward-Leonard controlled. Table II gives details of these drives at the blooming mill, and Table III the drives at the universal beam roughing and finishing mills. All the motors in Tables II and III are 230-V dc mill type of the AISE 600-series, shunt wound. They are supplied with power at 0–230–460 V from the variable voltage generators and develop twice standard horsepower at twice standard speed. For the blooming mill there are two motor generator sets each driven by a synchronous motor of 1000 hp at 1000 rev/min fed from the 2750-V supply. Each set has the motor in the centre, direct coupled to eight generators, four on each side. The generators are controlled by multi-field exciters which incorporate field forcing to obtain rapid response, and current limiting which is set at $2\frac{1}{2}$ times motor torque.

To keep the mill working in the event of a generator failure the two motor generator sets for the blooming mill are connected to the mill motors as shown in Fig.11. If there is a failure of any generator on a set the drive from that generator can be switched to the equivalent generator on the other set, leaving all the remaining drives normally connected. There is also a standby generator and exciter which can be switched in to replace any generator except those supplying the breast rollers. In the event of a complete failure of a set, all the drives on that set can be connected in series or in parallel and in some cases in either with a drive supplied from a generator on the other set and each group controlled together.

TABLE III Details of Ward-Leonard drive at universal beam roughing and finishing mills

	Motors, hp	Speeds, rev/min	Generators, kW	V
Approach roller tables	3, 100/200	0–485–970	3, 160	0/460
Front roller table	1, 75/150	0–515–1030	1, 160	0/460
Back roller table	1, 75/150	0–515–1030	1, 160	0/460
Runout roller tables	3, 100/200	0–485–970	3, 160	0/460



11 *Ward-Leonard connexions for blooming mill*

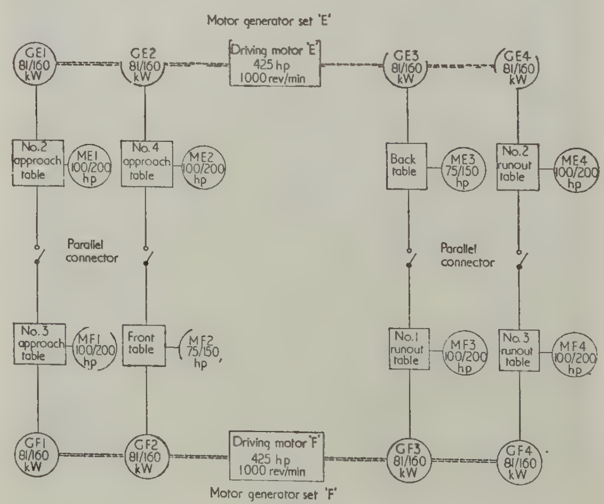
For the universal mills the connexion between the auxiliary motors and the generators is as shown in Fig.12. There are two sets for each mill, each set is driven by a 425-hp synchronous motor at 1000 rev/min from the 2750-V supply. In the case of these mills there is no standby generator set but the drives are divided between the two sets, and again in the event of a complete failure of one of the sets the other can take over the supply of all the drives at a reduced speed. If only one generator fails then two of the drives can be coupled together from one of the other generators. When this is done it is always adjacent drives which are slowed down confining the interference to one area, which is considered to be better from an operational point of view that to have two separate parts slowed down.

There is another section of Ward-Leonard controlled auxiliary drives situated at the two hot saws, covering the finishing mill runout tables, the approach tables to each saw, and the runout from each saw. The same arrangement of two motor generator sets with standby interconnexions as at the universal beam roughing and finishing mills is provided.

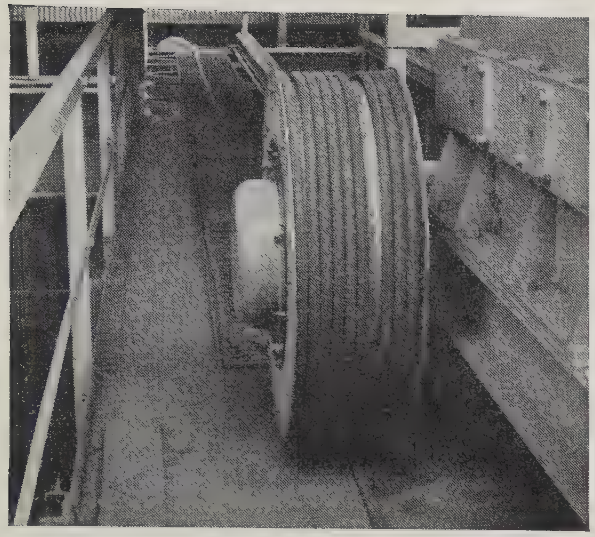
The remaining mill auxiliary drives requiring variable speed have 75% shunt 25% series, compound wound 230-V dc AISE 600-series motors with open-type contactor gear housed in the motor houses or brick contactor houses. Compound wound motors were chosen, so that they would have a series characteristic but would not overspeed on light load. The majority of the drives have dynamic braking and are controlled by three-step master controllers.

Cranes

The cranes are all supplied at 230 V dc and 1-h rated totally enclosed series motors are used; for the heavy-duty production cranes these are AISE 600-series motors, but for the light-duty maintenance cranes they are traction-type motors. The control is series for the traverse and travel motions with one or two steps of controlled plugging depending on the weight of the crane, the hoist and lower motions have series resistance control on hoisting with dynamic braking and potentiometer lowering. Two over-hoist shunt-type limit switches are provided, the first with backout and self-resetting facilities operating in the hoist motion control circuit, and the second is a hand reset type in the protective panel trip circuit. The latter is made hand resetting to ensure that the failure of the first limit is brought to the attention of the maintenance personnel. The control of the motions is by master controller and contactor panels except for motors of 20 hp and less on the lighter duty cranes where drum



12 *Ward-Leonard connexions for roughing mill*



13 *Typical torque tube contactless and springless cable reeling drum as used on cranes and transfer carriages*

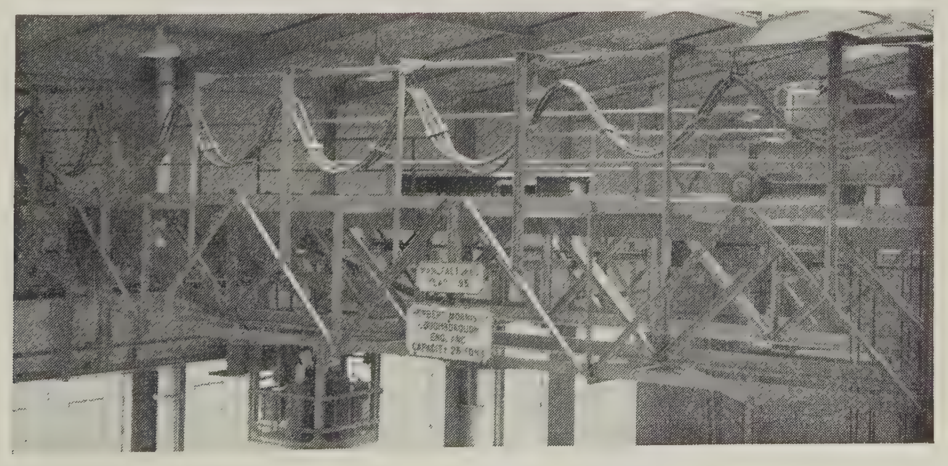
15 *Mercury and tungsten lighting fittings on swinging brackets attached to a roof walkway*

controllers are used. The contactor gear is mounted in contactor houses built into the crane girders whenever there is sufficient space. In general a crane is provided with a main hand-operated isolator for the power circuits and a switchfuse isolator for the lighting circuits, an air break hand-operated circuit breaker with overloads and no volt trip, a crane protective panel, and a separate contactor panel for each motion. The main power circuit isolator is key interlocked with the contactor house and with the cross traverse collector cage door if the collectors are of the open type, to prevent accidental contact with the live parts.

The downshop supply to the overhead cranes is by gravity collectors on high conductivity 4in × 4in × ½in mild-steel T-bars supported by brackets from the building crane girder, they are mounted one above the other but where the run is short and the loading light 3in × 3in × ⅜in angles are sometimes used. The electrical feed point to any track over 100 yd long is to a central position to reduce the voltage drop and on a track about 780 yd long there are two feed points with a section break to keep the systems separate. The dc supply voltage at the rectifier substations varies with load from 250 down to 240 V and the voltage drop in the cables and downshop conductor track is designed not to exceed 40 V.

Where the crane size and duty permits, the cross traverse supplies have been provided by flexible cables either by contactless and springless torsion tube reeling drums (Fig.13), or some form of looped cable usually on travelling runners but in some cases by a single loop (Fig.14). These methods eliminate the potential danger of open live conductors and result in a considerable reduction in weight.

A feature which is built into the controls of the soaking pit charger cranes enables the charger driver to control individually the pit lids and also to initiate the starting of the travel sequence of the ingot towards the blooming mill after it has been placed in the ingot receiving basket. It is accomplished by a single sectioned conductor track running adjacent to the charger downshop conductors, polarized relays in the control gear for the pit lids and in the basket control, and two buttons on the charger to select positive or negative of the dc supply. In addition to the pit lids and the ingot basket sequence the ingot transfer car running between the stripper bay and the soaking pit bay is controlled in a similar manner by the stripper cranes and the charger cranes. The charger or stripper crane must be in position opposite the pit lid, or



14 *Typical looped cable arrangement for crane cross conductors*

whatever is to be controlled, when the driver presses his button.

Hot saws

The two hot saws are each driven by a 500-hp 2750-V 1350 rev/min wound rotor type induction motor with automatic contactor type rotor starter retaining a ballast resistance in the rotor circuit to give 10% slip on full load. Since the first installation of the motors dc injection braking has been provided, and its use cuts down the run down time of the saw blade from 6 min to 20 s. The dc for the braking is taken from the 230-V shop supply and is connected through a resistance to two phases of the wound rotor.

Lighting

The lighting in all the mill buildings is designed to give an average illumination of 8 lm/ft^2 at floor level.

The design of the scheme has been based on the provision of easily accessible and changeable lamps and fittings. The lamps are 1000-W tungsten and 1000-W high-pressure mercury vapour in separate open-type fittings mounted in pairs at about 55 ft spacing and with two rows to an 88 ft 6in wide bay. The mercury lamps are a very efficient source of light, while the tungsten improves the resultant colour and provides an essential safeguard against the loss of light on a momentary dip in the voltage.

The mill building lamps are all hung on counterweighted swinging brackets from roof walkways (Fig.15) with a double pole isolator at each fitting for ease and safety of lamp changing. The lamps are switched in blocks of 12–13 using 75 A 3-phase and neutral contactors, push-button controlled from floor level.

The illumination of the stockgrounds and approaches to the buildings is provided by 1000-W high-pressure mercury vapour lamps mounted on the parapet of the building at a height of 35–40 ft and railway sidings away from the buildings are illuminated by a multiple arrangement of 1500-W tungsten fittings mounted on 150-ft towers. These towers are spaced from 1200 to 1800 ft apart and an illumination of 0·25 lm/ft^2 is obtained.

Communication

The plant is provided with dial-type telephones on the works automatic exchange and the mill buildings have cable capacity from the exchange for 200 works automatic and GPO telephones. In addition there is a loudspeaker system comprising a number of ring circuits each fed from a 60-W amplifier, linking closely associated sections of the plant such as the control pulpits at the blooming mill, the shears, the beam roughing and finishing mills, and the hot saws. A public address system is provided to give simultaneous instructions to the whole plant, or for locating personnel needed to deal with a breakdown.

Cables

Both paper-insulated and varnished cambric-insulated lead sheathed and wire armoured cables have been used for high tension and some low tension work, PVC and Butyl-insulated cables for the majority of the low tension ac and dc cabling, and some MICC cable on ac only. The big advantage of the PVC and the Butyl cable over the paper–lead cable lies in the ease with which they are jointed and terminated. Both armoured and unarmoured PVC cables were used in the smaller sizes of cable and were laid in trenches on hangers and buried in the ground. The Butyl insulated neoprene sheathed cables were only used in prepared ducts or on cable trays but were given the same current rating as for the same core size in paper–lead cable. The majority of the cable runs to mill auxiliaries are no more than 60 yd long and although the cost of the Butyl insulated cables was more than for paper the time saved in terminating and the cost of terminating made the use of Butyl cable more economic. The lengths of cable installed for the blooming, the beam mill roughing and finishing, sawing, and cooling banks sections of the plant add up to over 100 miles.

Besides using cable trenches, which were rarely entirely for cables, concrete underground tunnels were provided for cabling between the motor houses and from the motor houses to other sections of the plant, and where possible they were used as air ducts to the force ventilated mill auxiliary motors and main drive motors.

Development of electric drives and control for high-speed tandem cold-reduction mills

H. D. Morgan, D.F.H., and P. E. Peck, B.Sc., A.M.I.E.E.

SYNOPSIS

After a survey of the development and techniques involved in cold rolling, the specific problem of tandem rolling is considered. The evolution of drives and requirements of machines are then discussed and details given of typical regulating systems for stands and reels. Automatic gauge control methods are described, and then practical details are given of protection, ventilation, and maintenance considerations. Finally a recent four-stand mill installation is described and illustrated. 1953

INTRODUCTION

Tandem mill operation

THIS PAPER deals with electrical problems and their solution. However, it may be of interest to touch briefly on the historical development of cold rolling, as this leads logically to an examination of the multi-stand uni-directional mill which forms the basis of this paper.

It may not be generally realized how long the rolling of metal has been practised. The first design for a four-high cold mill was sketched by Leonardo da Vinci in the year 1495. This had work rolls of about 2in dia. × 12in long with two short back-up rolls about 2in long supporting the centre of the work rolls.

The earliest reversing mills which were used for rolling lead sheet probably for sheathing ships' bottoms, of the type illustrated in the AISE Yearly Proceedings 1947, originated in England about the end of the 17th or beginning of the 18th century. The Swedish technician Pohlem, who died in 1751, described the principles of the four-high mill for flat rolling with small diameter wrought iron work rolls backed up by larger diameter cast iron rolls 'because small rolls possess much more power of stretching [elongating] the material than did larger ones'. The cold reduction of steel strip was first proposed by John Westwood in 1783 for the manufacture of watch springs.

In 1864, however, the development of the three-high mill by Lauth, who patented the use of a smaller diameter middle roll, made the cold rolling of steel a practical industrial process.

Of the several types of cold mills in use today, the relative merits of three will be assessed. These are (i) Sendzimir or cluster mill, (ii) single-stand four-high reversing mill, and (iii) multi-stand four-high tandem mill.

Sendzimir mill

The cluster mill is a single-stand reversing mill which makes use of very small diameter work rolls to achieve high reductions per pass. Despite the small diameter of the work rolls, great rigidity is achieved by the arrangement of intermediate and back-up rolls. The two arrangements generally used are shown in Fig.1 and these are generally referred to as type 1–2–3 and type 1–2–3–4. In the former, each of the work rolls is backed by two intermediate rolls which, in turn, are supported by three larger diameter back-up rolls. In the 1–2–3–4 arrangement, the work rolls are supported by two intermediate rolls which, in turn, are supported by three second intermediate rolls and four back-up rolls.

The back-up rolls consist of a series of roller bearings carried on eccentric sleeves on shafts which are supported in closely-spaced saddles in direct contact with the mill housing. The rigidity of this arrangement enables sections to be rolled with great accuracy.

The relative distance between work rolls can be altered by rotating the eccentric sleeves on the back-up rolls. This replaces the conventional screwdown system.

In the 1–2–3 arrangement the four intermediate back-up rolls are driven and in the 1–2–3–4 arrangement, the outer second intermediate rolls are driven.

This type of mill is often used for rolling alloy steels, for example, 36in wide 18/8 stainless steel can be reduced from 3·1 mm to 0·46 mm in 11 passes, and silicon steel from 3 mm to 0·35 mm in six passes, both without intermediate annealing. Effective use is also made of these mills for rolling hard aluminium alloys.

In common with the single-stand reversing mill, this is not a high-production unit, but these mills are being contemplated for speeds up to 3500 ft/min. For equal size the weight and cost is substantially less than the conventional four-high mill, and within its particular field it has much to commend it.

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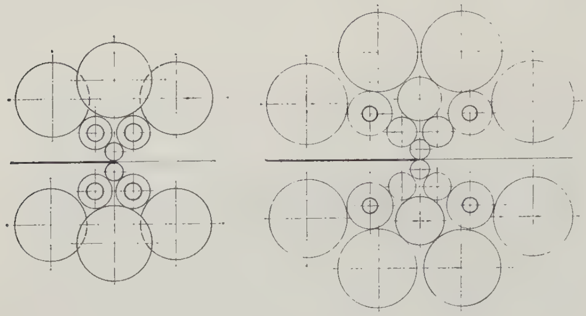
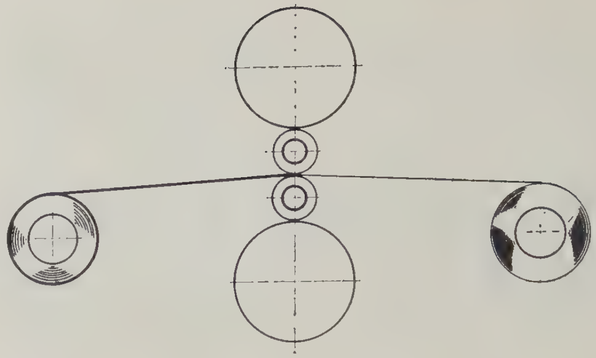


1 *1–2–3 and 1–2–3–4 arrangements of rolls for a Sendzimir mill*



2 *Four-high reversing cold mill with reels*

Single-stand four-high reversing mill

The principle of this has been known for many years and makes use of the conventional arrangement shown in Fig.2.

Here the work rolls are usually 16in to 21in in dia. and the back-up rolls 42in to 56in in dia. The work rolls are driven and screwdown is applied to the back-up rolls. In spite of the rigidity imparted by the massive back-up arrangements, the work rolls flex under the rolling forces used and the wider the mill the greater is the tendency for this to happen. Therefore, for sheet or tinplate the work rolls are usually 'crowned', i.e. the diameter is greater at the centre than at the ends of the rolls by about 0·001in in mills 40in wide, to about 0·006in on the widest mills. Under some conditions parallel rolls are used.

Reversing mills usually require about five passes when rolling tinplate and three passes when rolling relatively heavy sheet products. The output is considerably lower than is possible on tandem mills, so that although it is a very flexible arrangement the reversing mill is inherently a low-output unit, albeit much cheaper to install than a tandem mill. It is thus more suitable for dealing with small quantities of specialized products.

The uni-directional tandem mill

This arrangement usually consists of two to five stands, the material being in all stands together. Arrangements are provided to support the coil of material to be rolled and on the outgoing side there is a recoiler designed to maintain tension in the strip.

The first tandem strip mills were built around 1920. They were usually arranged as four-stand mills powered by motors up to 300 hp supplied from constant voltage busbars. Speeds were controlled by steps of armature resistances followed up by field weakening usually of a ratio of 2 to 1.

The metal is threaded through each stand and on to the reel at 1/10 to 1/20 full speed and the mill is then accelerated to the rolling speed. It is important that the mills all accelerate or decelerate together so as to control the inter-stand tension. The difficulties of doing this satisfactorily by resistance control can well be imagined; indeed, it was not unusual to roll with loops between stands, so as to allow the operators to see what was happening and adjust the stand speeds appropriately.

This led to the application of adjustable voltage control for such mills since this can readily be arranged to provide constant torque which is required to maintain constant inter-stand tension under conditions of changing speed.

One of the earliest tandem mills to be put down in this country was a three-stand mill built by Krupp for the non-ferrous trade, and was erected at Witton for ICI in 1932. It is interesting to note that this mill in modernized form is still in operation. The main details of the original specifications were:

Size	12in × 35in × 32in
Rolling speed	Stand A—90 ft/min Stand B—185 ft/min Stand C—250 ft/min
Main drive	Motor generator set, 1000 hp synchronous motor driving three 123/300 kW generators at 1000 rev/min Main drive motors, three 152/380 hp dc constant torque (Ward-Leonard) 1000 rev/min
Rolling load	600 tons per side. Back-up rolls SKF four-row self-aligning roller bearings based on a life of 3000 h

The specified rolling practice was to reduce 26in wide × 1000 lb coils of copper alloys, e.g.

70/30 brass annealed	0·080in—0·030in
	0·160in—0·080in
Copper hot rolled	0·180in—0·030in

each in two passes.

The modern uni-directional tandem mill is a very elaborate and expensive unit but is capable of high production. Five-stand mills for tinplate gauges, that is, 0·005in–0·014in, are commonly in use for finishing speeds up to 6000 ft/min and speeds up to 8000 ft/min are contemplated. Representative rolling schedules are given in Table I. Such mills are capable of averaging outputs of 500 tons/shift.

Material for the car body trade, refrigerators, etc., in the range 0·024in–0·039in is usually rolled in

TABLE I Typical rolling schedules for five-stand mill

Incoming gauge	Finished gauge	Width, in	Stand speeds, ft/min 1	2	3	4	5	Reductions, % 1	2	3	4	5
0·069	0·0071	28¾	380	675	1200	2000	3500	5·4	43	44	40	43
0·085	0·0088	34⅝	500	800	1400	2250	4000	17·6	37·5	43	38	44
0·079	0·0099	30½	550	850	1400	2250	4000	16	35	39	38	44
0·085	0·0093	34¼	500	800	1425	2250	4000	12·5	37·5	43	37	44
0·079	0·0093	33	500	825	1425	2250	4000	6	39	42	37	44

TABLE II Typical rolling schedules for four-stand mill

Incoming gauge	Finished gauge	Width, in	Stand speeds, ft/min 1	2	3	4	Reductions, % 1	2	3	4
0·140	0·062	30–50	1170	1540	2080	2200	17	24	26	5·5
0·120	0·048	30–48	1340	1710	2340	2500	21·5	25	27	6·5
0·100	0·039	30–48	1250	1740	2400	2640	18	28	27·5	9
0·085	0·028	30–40	1200	1760	2520	2740	25	32	30	8
0·070	0·016	26–36	1110	1800	2860	3050	37	38·5	37	6

three- or four-stand mills and typical rolling schedules are shown in Tables II and III. Outputs of 700 to 1000 tons/shift can be maintained.

Materials in between these two gauges, for example high silicon electrical steels and material for the sheet galvanizing trade, usually in the range of 0·016–0·025in, are commonly rolled in four-stand mills, an excellent example of which is shown in Fig.11. This mill, which is described in a later section of the paper, was commissioned in 1959 and has a number of original features.

PROBLEMS OF ROLLING ASSOCIATED WITH MILL AND DRIVE CHARACTERISTICS

To appreciate the problems surrounding the design of the drives and control gear it is necessary to understand what happens during rolling. The generally accepted plastic flow theory states that the vertical compressive stress plus the horizontal tensile stress must equal the yield stress at every point in the roll gap. The significance of this statement is, of course, that during rolling any change in either or both of the forward and backward tensions results in a change in roll separating force and this, in turn, changes the roll gap and hence the thickness of the outgoing steel strip. The sense of the change is such that tension increases cause reduction in strip thickness. The relation between the changes is a linear one over normal loads, i.e. over the range of loads for which the stand housing obeys Hooke's Law. At extremely low loads and again at very high loads, especially where roll flattening has to be taken into consideration, non-linearities occur.

In what follows, we use the term 'hard drive' and 'soft drive'. By that is meant the amount by which a motor will slow down when it comes on load, or speed up as load is thrown off. This is usually expressed as a percentage, for example, 4% at full load. The less a motor slows up as it comes on load, the harder the drive is said to be and vice versa.

Before attempting to assess the required characteristics of a multi-stand tandem mill drive, it is necessary to study the physical behaviour of a mill during rolling. This is best done by considering the effects of disturbances on the individual outputs of each stand of the mill in turn and the changes which must take place to restore the concept of equal outputs, i.e. equal volumes of steel roller per unit time by each stand. Hessenberg and Jenkins[1] have made a mathematical analysis of the problem and shown how quantitative results can be calculated, but it is sufficient here merely to indicate its nature.

TABLE III Typical rolling schedules for three-stand mill

Incoming gauge	Finished gauge	Width, in	Stand speeds, ft/min 1	2	3	Reduction, % 1	2	3
0·084	0·031	48	625	1050	1120	40·5	34	6
0·084	0·035	48	725	1060	1120	36	31·5	5·5
0·062	0·031	48	750	1065	1120	29	26	4·5
0·105	0·048	48	920	1270	1400	33	27	6·0
0·084	0·048	48	855	1120	1200	30	24	7·0

To take the two extremes, a mill stand can either be springy with a hard drive, by which is meant one with small load/speed droop, or be a rigid stand with a soft drive. The effect of increased forward tension on the output of each of these mill types differs. As has been explained, increased forward tension will result in thinner strip being rolled in each case, but more so in the springy mill and since there will be no speed change associated with a hard drive, the reduced thickness must result in reduced output. In the second case, the thickness reduction is less and it is accompanied by a speed increase which is sufficiently large to overcome the reduction in output due to change in thickness. The result is an increase in output. The former mill is called undercritical and the latter overcritical. It is important to note that output changes caused by tension changes in the case of undercritical mills are due to gauge changes and in the case of overcritical mills to speed changes. The effect of increased back tension is always to reduce the output of the mill.

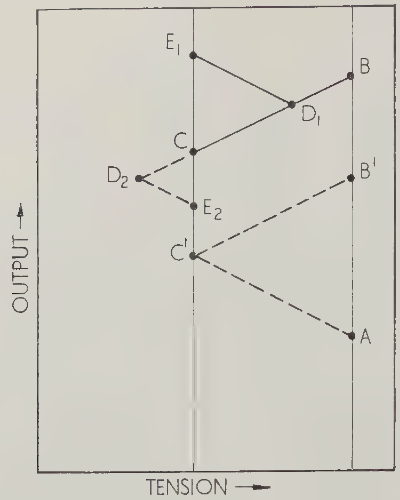
It is a comparatively simple matter to show that if two stands are running in tandem the raising of the screws of stand 2 will cause an increase in inter-stand tension, which results in the case of undercritical mills in reduced output and of overcritical mills in increased output. In the former case, the reduced output is almost entirely in the form of a gauge change, i.e. raising stand 2 screws produces thinner strip, whilst in the latter case the increased output results in thicker strip being produced.

Consider now the changes resulting from the raising of the screws of stand 1 of a two-stand mill. This is represented diagrammatically in Fig.3, which shows separately the changes due to speed changes and those due to gauge changes. A represents the output of both stands before the change.

When the stand 1 screws are raised, the material issuing from stand 1 increases in thickness and the load on stand 1 motor reduces and the stand speeds up. AB^1 represents the immediate increase in stand 1 output due to this increase in speed. The increased speed now causes a progressive reduction in tension which causes stand 1 to slow down and stand 2 to speed up, the tension stabilizing when the exit speed of stand 1 matches the entry speed of stand 2 at point C^1 in the diagram. B^1B represents the immediate increase in output of stand 1 due to the increase in gauge.

In the meantime the thicker material travels towards stand 2 and during this period the output of the two stands is not equal. Once the thicker strip enters stand 2 its output increases and changes must take place to ensure the outputs of both stands become equal.

If at first stand 2 output is greater than stand 1, the



3 *Tension and output changes when threading a mill*

tension will rise again, speeding up stand 1 and slowing down stand 2 until balance is reached at the point D_1; conversely if stand 2 output is at first less than stand 1, balance will be reached at D_2.

While the above may give some indication of the rolling problem and the extent and duration of the disturbances which can arise when several stands are run in tandem, it does not give an immediate answer to the question of what mill drive characteristics are desirable. One further mill characteristic has to be considered. This is the amplification factor.

If the incoming gauge to a mill stand increases, the outgoing strip thickness may increase by a percentage greater than, equal to, or less than the incoming change. The ratio of the outgoing percentage change to the ingoing percentage change is termed the amplification factor. Obviously, it is advantageous that a mill should minimize gauge variations and it is interesting to examine the effect on the overall amplification factor of varying the droop of the stand drives. For the sake of simplicity consider again a two-stand mill with a very soft drive. First, since the drive speed changes involved are large compared with changes in slip in the roll bites, it can be seen that the product of speed and gauge of strip emerging from stand 1 must equal a similar product from stand 2. Second, tension changes affect mainly speed changes so that the effects on gauge are small. Thus the overall amplification factor of such a mill approximates to the product of the individual stand amplification factors, e.g. for a stand amplification factor of 1·1 the overall amplification for the two stands will be 1·21.

In the case of a very hard drive, not only do the products of the speed and gauge following stand 1 equal those following stand 2, but since the speed ratio is constant the thickness ratio must also remain constant. The increase in strip thickness entering stand 2 has a similar effect to that described following the raising of stand 2 screws, viz. an increase in inter-stand tension which has the effect of reducing the output gauge change to obtain an output equal to that of stand 1 and maintain the thickness ratio determined by the stands' speed rates. It has been assumed that the amplification factor of each stand considered separately is greater than one, which appears to be the general case for tandem mill stands. It can be shown, however, that if two stands each with an amplification factor of less than one are run in tandem with stiff drives, the overall amplification factor becomes nearer to unity.

The desirable mill drive characteristics now become clear: (*a*) the mill should be able to accelerate and decelerate without appreciable inter-stand tension changes; (*b*) it should be capable of accelerating and decelerating rapidly; (*c*) it should not amplify incoming gauge changes; (*d*) similar adjustments to the mill should produce similar results at all speeds, e.g. a small stand speed-setting change should produce the same change in inter-stand tension at all run speeds; (*e*) it should be sufficiently soft to permit the mill to be threaded. (Very critical setting up should not be necessary as incoming strip may vary appreciably from its nominal thickness); (*f*) in addition to (*e*) and in conflict with (*d*) speed effect materially influences the degree of hardness which can be used during acceleration. Speed effect is the name given to the phenomenon exhibited by mills in that if screw settings and inter-stand tensions are maintained constant and the mill speed raised, the outgoing gauge will reduce by as much as 10% as speeds in excess of 1500 ft/min are attained. A partial explanation is that the thickness of the oil film in the customary flood back-up roll bearings increases with increase in speed.

A number of stands rolling in tandem behave almost as a critical mill[1] so that the influence of inter-stand tension between, say, stands 4 and 5 of a five-stand tinplate mill will change only slightly the output from stand 4. Thus the speed effect will tend to reduce the output of stand 5, if its drive is very stiff, and inter-stand tension between stands 4 and 5 will drop or these stands attempt to balance their outputs. Should the magnitude of this change prove unacceptable, it is necessary to soften the drive of stand 5.

It can thus be seen that the material and its dimensions influence the drive regulation which is permissible. If large tension changes can be accommodated, the advantages of a hard drive, i.e. the minimizing of gauge variations, can be utilized, but if the rolled material cannot stand such changes it is necessary to soften the drives. Again if a material such as aluminium is being rolled, the roll separating force especially on the last stand of the mill may be so low that inertia compensation for the drive, couplings, and rolls may become of very considerable importance in ensuring uniform accelerations and decelerations.

It is equally necessary to keep a close control of the tension between the reel and the last stand. For the best rolling practice the electrical circuits must take into account not only the changing diameter of the coil as it builds up, but also inertia effects of the coil during acceleration and deceleration. In modern high-speed tinplate mills, because of the latter effect, it is not unusual to have to apply reverse torque to maintain correct tension, and therefore the coiler mandrel should be designed to withstand reverse torque.

HISTORICAL DEVELOPMENT OF DRIVES

Mention has already been made of the fact that the earliest tandem cold mill drives had rheostatic starting of the individual machines on a common constant voltage supply. Clearly this could give only the crudest form of drive, and the need to accelerate and retard all stands in step soon led to the use of a Ward-Leonard supply system, in which, although the motors

were still connected to common busbars, they were at least all subject to simultaneous voltage changes.

The constant demand for greater outputs however emphasized the limitations of this system. As a result of higher speeds, the rates of speed change were also increased, and the differing inertia effects of the various machines resulted in loss of synchronism during acceleration and retardation. Each motor has to be set at a different speed and consequently, even in cases where duplicate machines are used throughout, the accelerating current varies widely. One development was to introduce a booster in series with each armature to permit regulating voltages to be introduced into each armature circuit. The prime function of this arrangement was to provide 'IR drop' compensation, thus enabling the machines to follow the busbar voltage changes more closely in spite of differing load currents.

On some of these earlier mills a feature known as 'taper tension'[2] was added. The idea of this was to adjust the relative speeds of the stands during speed changes so as to alter the inter-stand tensions with speed. The purpose was the better maintenance of gauge and was an endeavour to counteract the relatively small amount of speed effect experience with these earlier, and slower mills.

However, as already explained, with higher mill speeds the change of tension due to speed effect can be so great that steps must be taken to 'soften' the drives, i.e. increase the droop progressively as the speed is reduced so that taper tension control as such is no longer used.

Provision was made on some of the mills installed in the 1930's to control inter-stand tension, using tensiometers operating on small boosters in the stand motor field circuits. As far as can be ascertained this was little used.

Early installations made use of moving coil carbon pile or vibrating contact type regulators, but the development of quick response regulators during the war years, along with increased understanding of system stability opened the way for a big stride forward in the control of these mills. Furthermore, the need for wide speed ranges to cover a larger number of schedules led to the common busbar system being abandoned in favour of individual generators for each stand. The new regulating systems permitted these separate circuits to be kept more closely in step than had been possible even with common busbars on the earlier mills. The latest regulating devices have developed from rotating regulators, such as amplidyne, etc., to 50 cycle and more recently 400 cycle magnetic amplifiers with the attendant advantages of static equipment.

The increased powers for the higher speed mills has led to the use of multiple armatures for the drive motors, in order to keep the inertias down. In this country it is usual to connect these in alternate series with generator armatures, a system which provides good load sharing between machines and permits the optimum voltage to be adopted from the machine design point of view, without excessive voltages round the loop. It is also the most economical arrangement from the viewpoint of circuit breakers for protecting the loop.

On the most recent drives the power requirements of the later stands are such that at least four, and in some cases six, armatures are required. It then becomes a proposition to use a twin drive. The small roll centres necessitate off-setting gears to step the drives out to the motor centres. On very high-speed mills, the roll speed would, in any case, be too great for satisfactory motor design and these gears permit the machine speed to be selected for the best performance.

On a four-stand mill where the powers on stands 2, 3, and 4, or even on all four stands, may be the same it is possible to use duplicate twin drive motors throughout, the correct roll speeds being obtained by the ratio of the off-setting gears.

SPECIAL FEATURES OF TANDEM MILL MOTOR DESIGN

A modern tandem cold mill imposes very exacting demands upon the motor designer. The main factors required are:

(i) very low inertia
(ii) wide speed range by field control (especially so in the case of reel motors)
(iii) an inherent droop characteristic which is linear from light load up to the operating speed, over the whole speed range
(iv) good transient performance with sudden load and speed changes.

To reduce the inertia to a sufficiently low value it is necessary to use small diameter motors, and a comparison of pre-war and post-war designs will show the progress in this direction for tandem cold mill drives. Where a typical pre-war stand motor would have had a core length to armature diameter ratio of 0·3–0·5 it is now common practice to use machines in which this ratio is 0·7–1·0. For a reel motor the ratio is sometimes as high as 1·5. Such proportions would have been unthinkable a few years ago.

In the same period the maximum powers per stand have risen from 1000/1500 hp up to 6000 hp, while reel powers have risen from 200/500 hp up to 1400 hp. These figures apply to drives in this country. Still higher powers have been used in the USA.

The longer core lengths and smaller diameter of the modern motors have made attainment of good commutation more difficult, but by paying careful attention when designing the motors to the factors affecting commutation entirely satisfactory performance can be achieved. The correct design of the brush gear and selection of the right grade of brush are obviously of great importance, as also the correct design and adjustment of the commutating poles.

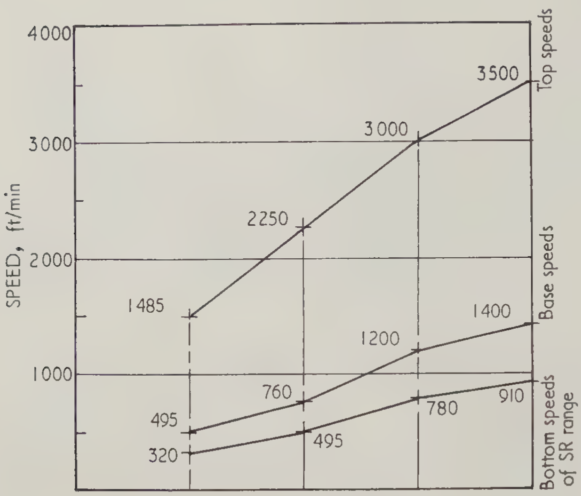
Accurate compensation of the armature reaction under the main pole and the attainment of good commutation are important factors in obtaining a linear speed/torque characteristic on machines with wide speed range by field control.

STAND CONTROL SYSTEM

Control requirements for the main drive

One of the primary requirements for the drive for a tandem cold mill is that it should be adjustable over a wide range of speeds to accommodate a large variety of rolling schedules.

The speed cone of a typical four-stand mill is shown in Fig.4 and illustrates the range of control required on each stand.



4 *Speed cone for typical four-stand mill*

After setting the relative speeds of the stands for a particular rolling schedule, the speed relationship must be maintained within close limits by the stand regulating system during acceleration and retardation of the mill and during load changes resulting from variations of gauge and strip hardness or from operation of the screwdowns. In addition a suitable tension in the strip between the stands must also be maintained under all conditions and it is essential that the mill should recover and settle down rapidly after being subjected to load and speed disturbances.

Main drive control system

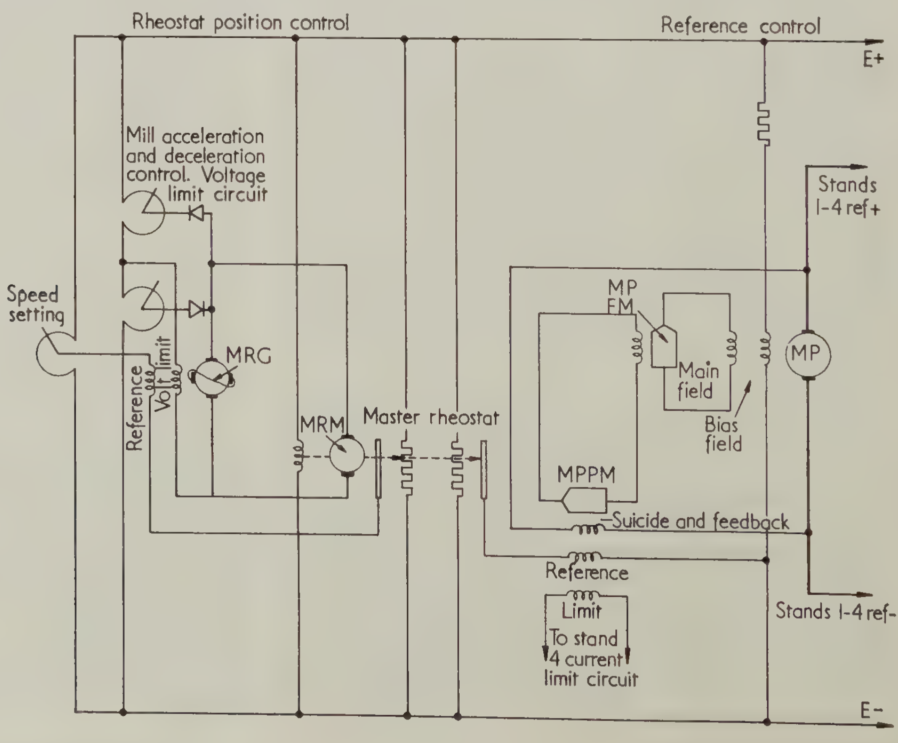
Mill reference control

In general, the basic control system for a multi-stand cold mill consists of a regulated master reference voltage which is supplied to each stand control circuit, and by increasing or decreasing this reference the speed of the whole mill can be raised or lowered. For individual adjustment of a particular stand speed within the limits of the speed cones, separate adjustment of each stand motor field is provided. The field is normally set approximately before running the mill up to speed, and a vernier on the field setter is used to re-adjust the stand speed, if necessary, during rolling.

A typical mill reference control is shown in Fig.5. The reference voltage for the stands is supplied by the master pilot generator (MP) which is controlled from the master rheostat via magnetic amplifiers MPPM and MPFM. This forms a high gain voltage regulator making MP-output voltage directly proportional to the positions of the master rheostat and, therefore, the position of the master rheostat arm determines the reference voltage and hence the speed of the mill. This arm is driven by a motor MRM supplied from an amplidyne MRG which acts as a position control regulator. The operator's rheostats which preset the thread, weld, and run speeds are mounted on the mill cabinets, and momentary depression of a push-button will select a position reference for the master rheostat arm and cause it to run to 'thread', 'run', or 'stop', depending on which button is pressed. Pressing 'hold' immediately stops the rheostat arm moving and causes the mill to run at an intermediate speed.

The speed at which the rheostat arm moves determines the rate of acceleration and deceleration of the mill, hence by limiting the amplidyne voltage to a preset value the rate of change of mill speed can be governed. Operators' rheostats connected in the voltage-limit circuit provide separate means of adjusting the acceleration and deceleration rates.

'Mill speed raise' and 'mill speed lower' push-buttons select maximum or zero position reference respectively, and, at the same time, select a low amplidyne voltage-limit reference. On pressing one of these buttons the mill speed will therefore increase or decrease at a slow rate until the button is released.



5 *Master reference control, schematic diagram*

To stop the mill under normal conditions in the minimum possible time, the master pilot generator regulator is switched to zero reference. If, however, the reference voltage was allowed to fall unchecked the regenerative current in the stand motor armature circuits would be excessive. During stopping, therefore, the MP regulator is used to control stand 4 current, limiting the regeneration from stand 4 motors to a maximum safe value by controlling the decay of reference voltage.

Stand speed control

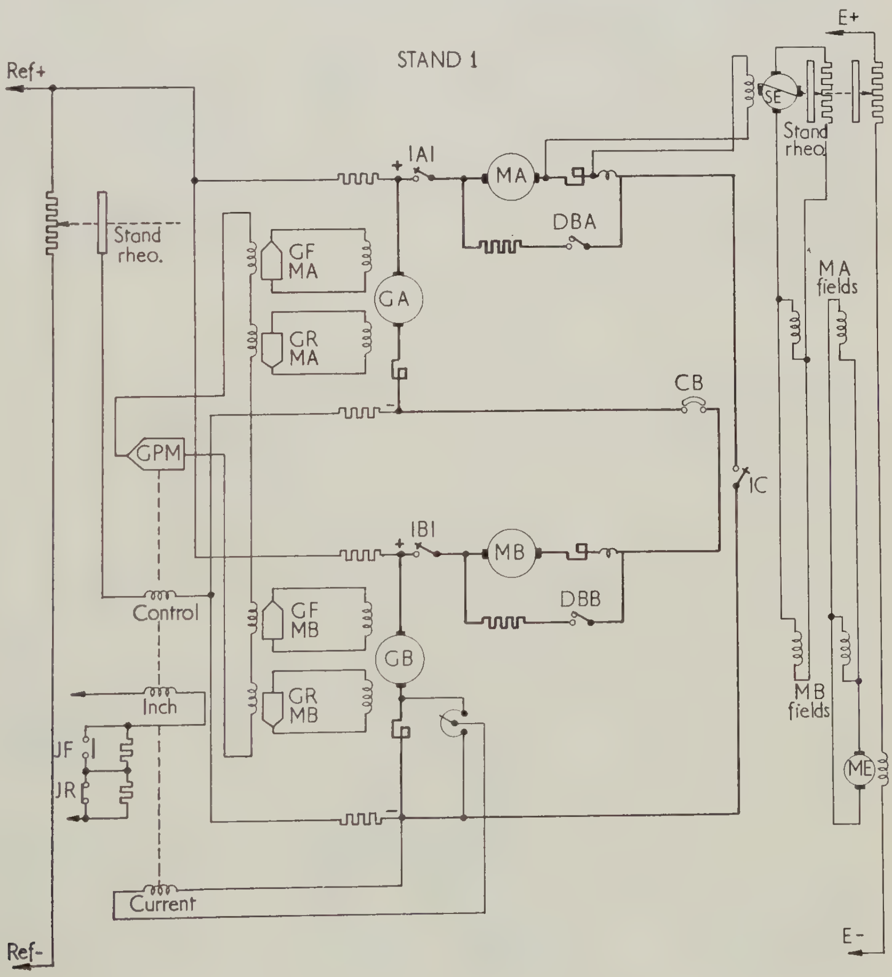
From what has already been said about general drive characteristics it will be recalled that in order to reduce accelerating time to a minimum it is necessary to use special low inertia motors, often with two or three units. An elementary diagram for a two-unit stand is shown in Fig.6. The motors and generators are connected in a series sandwich arrangement with the average generator voltage regulated to correspond to the mill reference voltage by magnetic amplifiers GPM, GFM, and GRM, etc. Any difference between the average voltage of the stand generators and the reference voltage causes current to flow in the control winding of the pilot amplifier, GPM, exciting the generator main fields through push-pull amplifiers GFM and GRM, etc., to correct the difference. Some voltage difference must exist to maintain excitation, but the amplification of the voltage-regulating loop is such that the generator voltage always corresponds closely to the reference voltage.

Motor speed varies with the load current because of armature resistance and armature reaction. Load compensation is therefore introduced to maintain the stand speed relationship within definite limits in spite of varying load, by increasing the stand generator voltage by an amount proportional to motor armature load current. This is achieved by connecting a current control winding on GPM to a circuit fed from the voltage drop across the generator compole and compensating winding. The voltage thus introduced into GPM current control winding can be varied by means of a load compensation rheostat on the operator's panel.

The speed droop due to load is a much greater proportion of actual speed when threading than when running. In order to give the ratio of these proportions the optimum value, a careful blending of motor compounding and load compensation is required, the degree of compounding being adjusted automatically so as to have the same effect at all speed settings of the motors.

Forward and reverse inching, by means of 'inch' switches on the mill cabinets, can be produced by varying the pilot amplifier GPM inch field winding. Stand 'creep' and 'speed-up' are produced in a similar manner.

Provision is made for interruption of the motor armature circuits in an emergency by means of high-speed circuit breakers, which are also capable of contactor duty on this type of application and therefore



6 *Stand speed control, schematic diagram*

make separate line contactors unnecessary. Dynamic braking contactors are used to connect resistances across the motor armatures for emergency stopping.

With the mill at rest any stand motor can be isolated by the mill operators from the stand control cabinet by means of the 'stand selector' switch which opens the line circuit breaker. Complete isolation of any armature is made possible by hand-operated isolating switches in the armature.

Twin drives

Mention has been made earlier of the use of twin drives on some of the latest and fastest drives. In these cases separate Ward-Leonard loops are used for the top and bottom rolls. Each is regulated to the Master Reference but means are provided for individually modifying the reference to allow for relative speed adjustment of the two rolls, thus enabling work rolls of different diameters to be used.

CONSTANT TENSION REEL DRIVE AND METHOD OF CONTROL

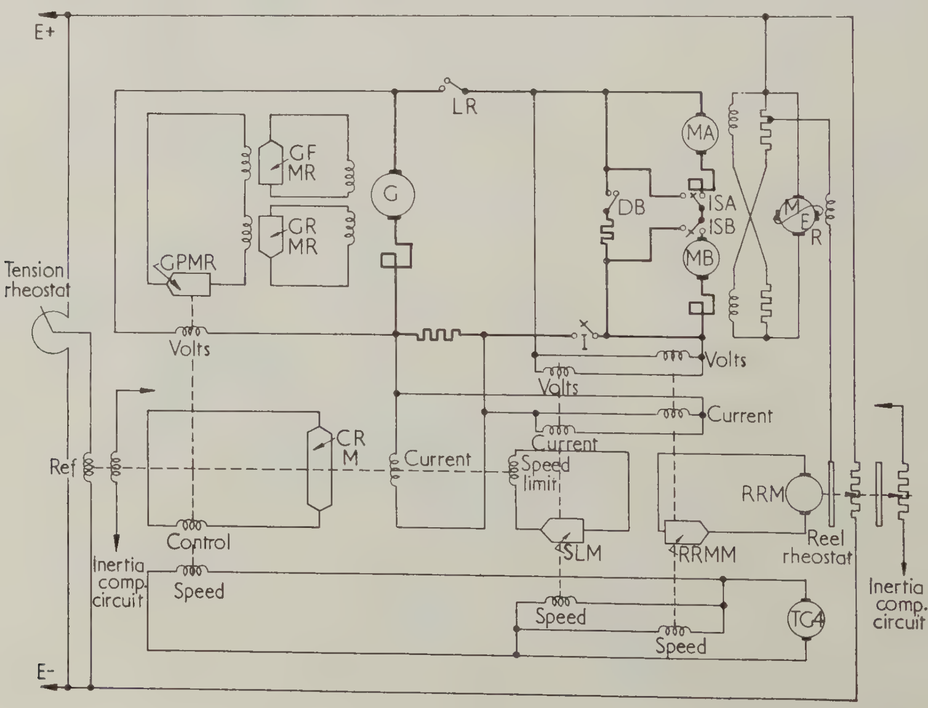
The strip leaving the last stand of the mill is coiled under tension on an expanded mandrel to form coils up to 6 ft dia., and as the tail end of the strip leaves the mill the reel is stopped and the mandrel collapsed so that the coil may be easily removed. During this period of coil removal another coil is usually being threaded through the mill, and by the time the front end presents itself to the mandrel, the mandrel has been expanded and restarted to run at threading speed with a belt wrapper in position to receive the next strip. Immediately the first one or two laps are made, threading tension is automatically applied and the belt wrapper is withdrawn. After the mill 'run' push-button has been pressed, running tension is established and for the rest of the coil constant tension must be maintained whether the mill is accelerating, decelerating, or running at constant speed with a gradual build up of the coil.

Constant tension is necessary in order to help maintain uniform gauge and good shape, and to give an even build-up of the coil and so avoid unnecessary delays in the next process.

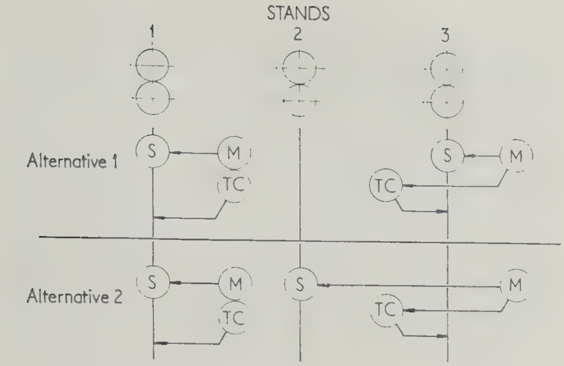
There are various methods of tension control each one suitable for different applications. The one described here has been developed over a number of years and is the most accurate of its type and therefore most suitable for high-speed tandem cold mills. The underlying principle is that, neglecting friction and windage losses, the electrical power ($V \times A$) is proportional to the mechanical power (speed$\times$tension), hence by making the reel motor voltage proportional to the strip speed the tension must be proportional to armature current, so by keeping the current constant, tension can be held at a definite value. Two separate regulators are therefore provided.

Volts/speed regulator

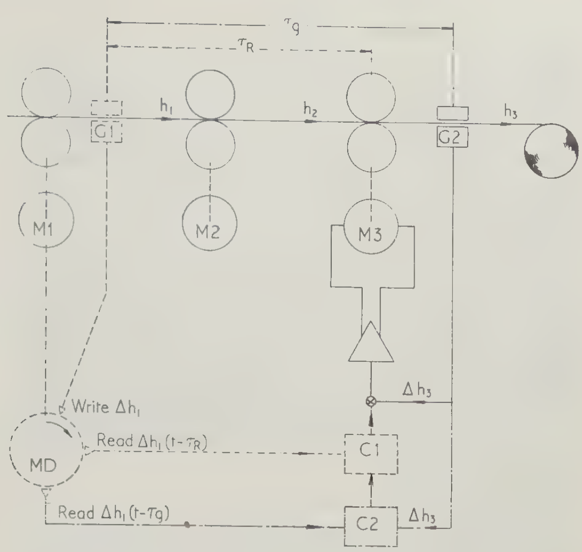
Referring to the schematic diagram (Fig.7) a voltage proportional to reel motor emf is compared with the output voltage of the tachogenerator driven by the last stand (in this case stand 4). This latter is a measure of strip speed. As the coil builds up, the reel motor tends to slow down and its armature emf decreases. The resulting difference between the two voltages causes a current to flow in a magnestat RRMM the output of which operates the reel rheostat to regulate the supply to the reel motor field. A current winding on RRMM compensates for any difference between terminal voltage and motor emf on load. The magnestat is purposely non-reversing so that the reel rheostat can only move in a direction to strengthen the motor field. The position of the rheostat is thus always a function of coil diameter, and therefore an auxiliary dial on the rheostat can be used to modify the inertia compensation signal fed into the current regulator. This is necessary because the combined inertia of drive and coil varies with build up.



7 *Tension reel control, schematic diagram*



8 *Automatic gauge control systems*



9 *Basis of alternative scheme*

Current regulator

A current regulating magnestat CRM compares the voltage drop across a shunt in the reel motor armature circuit with a reference set on the tension rheostat while the mill is operating. Any difference in excitation causes a current to flow in the reel generator regulating magnestat GPMR, adjusting the generator field and hence armature voltage by means of the push–pull generator field magnestats GFMR and GRMR to correct the error. When the mill is stationary the reference excitation for CRM is taken from a 'stalled tension' rheostat and when threading from a 'thread tension' rheostat. An inertia compensation winding on CRM modifies the current reference to maintain tension substantially constant during acceleration and retardation, whatever the coil diameter.

If the strip should break, tension will be lost and the motor will accelerate in an attempt to maintain its armature current. A speed-limit magnestat SLM is excited from the same sources, emf and speed, as RRMM. Under normal conditions, SLM is cut off and RRMM operates. When the motor accelerates the emf signal exceeds the speed signal, RRMM cuts off, and SLM comes into action, supplying a winding of the current regulating magnestat to hold reel motor speed to safe limits.

AUTOMATIC GAUGE CONTROL (AGC)

From what has gone before, it can be seen that the application of automatic gauge control to tandem mills involves more than simply measuring outgoing gauge and adjusting the screws on the last stand to keep it correct.

The influence of tension changes and speed effect on gauge have been dealt with. There is another factor, however, which has to be considered, namely work hardening. If the ingoing gauge increases and the screws on stand 1 are screwed down to compensate for this, the amount of work being done on the metal increases, and so its hardness increases. As this harder material enters subsequent stands it will be less deformed than the softer preceding strip, and so there is a tendency to roll back into the strip the variations in thickness corrected in the first stand.

The principles of gauge control on tandem mills hold good irrespective of the number of stands, so it is proposed to describe one system of control which was developed for a three-stand mill, and which illustrates one solution to the problem.

Figure 8 illustrates two alternative forms.

In alternative 1, the gauge is measured in stand 1 by means of a BISRA-type gauge meter which is monitored by an X-ray gauge between stands 1 and 2. This monitoring is necessary to allow for variations in roll and stand temperature, etc., and any drift in the circuitry.

In order to ensure that the correction to gauge achieved by adjusting the screws on stand 1 does not upset the tension settings through the mill, a tensiometer measures the tension between stands 1 and 2, and maintains it at a constant preset value by trimming the speed of stand 1.

There is also a constant tension control between stands 2 and 3 which maintains the preset tension by adjustment of the speed of stand 3.

The final outgoing gauge after stand 3 is measured by an X-ray gauge and any small variation from the desired gauge arising from variation of hardness or temperature changes in stands 2 and 3 is corrected by adjustment of the set point of the inter-stand tension between stands 2 and 3.

It has already been shown that the gauge of the metal issuing from the stand can be adjusted by means of varying the tension. Since, however, there is a limit to the permissible tension, this control is followed up by an adjustment to the screws on stand 3 should the required tension to correct the gauge exceed the permitted limits.

Alternative 2, which is very similar, is the one which was chosen. In this case, the screw adjustment to maintain the tension between stands 2 and 3 within permitted limits is done on stand 2. While this is not theoretically quite such a good arrangement, it is preferred in order to allow the mill operators unrestricted control of stand 3 for the purpose of maintaining good shape.

It may be of interest to touch on another system which has been suggested by the Russians.[3] So far as is known, this has not been applied to a mill in practice, but has been simulated on an analog computer, and its performance examined.

Figure 9 shows the basis of this scheme. The full lines show the conventional direct acting AGC in which a signal of final gauge deviation $\Delta h3$ is fed back to control the speed of stand M3.

Dotted lines show a method of open loop disturbance compensation in which a signal of early stage deviation Δh_1 is delayed by a magnetic drum MD to arrive at stand M3 at the same time as the affected portion of strip. If the compensating computer C1 correctly allows for the effects of inter-stand tensions and the response lag of M3 speed regulator, then it can effect all the necessary correction without recourse to the direct acting feedback link.

However, the mill transfer function depends on time, temperature, lubrication, etc. Hence a third closed loop is added (shown chain dotted) in which a second signal Δh_1 (t–Tg) is delayed by the time interval between the two gauges G1 and G2 and then compared to the final deviations Δh_3 in the optimizing computer C2, which modifies the equations of the compensator C1 by expected trial and errors to minimize the final gauge deviation Δh_3.

Electronic analog simulator studies have confirmed that C2 must modify both the effective dead time and the attenuation of C1, but the effects of back-up roll eccentricities in stands 2 and 3 do not appear to have been simulated.

The open loop disturbance compensator is unlikely to cope with these, and it would appear that the optimizing loop is too slow to be effective.

FAULT PROTECTION AND INDICATION

An equipment with such a high intrinsic output and earning capacity as a tandem cold mill must be designed with effective protective features and with means for immediate indication and rapid location of faults. On the high-tension ac side protecting the synchronous motor and its starting reactor is the usual overload, earth leakage, and Merz-Price protection and in the particular case of the four-stand mill at the Abbey Works in addition to thermocouples indicating stator winding temperature there is also continuous reading of rotor temperature.

The most onerous duty falls upon the protection for the Ward-Leonard circuits and the regulating systems feeding them. Each Ward-Leonard loop has one or two type RLR circuit breakers depending upon whether the mill motors are double or triple unit. The limiting criterion is the desirability of preventing voltages greater than 1200V to earth in the event of fault or overload conditions and it is for this reason that two breakers are used on the triple unit sandwich circuit. Normally the system runs at ± 300 V to earth there being earth leakage detection and protective devices fed from the averaging voltage feedback from the generators. The type RLR circuit breakers are of the withdrawable truck type, and a spare is kept. The circuit breakers have an inherent instantaneous overload setting of $3 \times$full load in both directions and in addition there is a normal overload relay set at $2{\cdot}4 \times$full load forward and $1{\cdot}7 \times$full load reverse, backed up by an inverse time relay set to trip at twice full load after 15 s. These both trip the circuit breaker.

There are various methods of stopping the mill. The normal run down from run speed to thread speed is done on the motor operated rheostat and is the usual method when rolling. A normal stop to rest from any speed is done by reducing the master reference as fast as possible under the control of current limit from the last stand; this is a controlled stop with the stands remaining in synchronism. In addition, there is an emergency stop applying dynamic braking to all stands and reel.

A number of protective devices are provided to cover various eventualities and these are grouped to stop the mill by different methods according to the nature of the fault. For example all overloads trip the breakers and apply dynamic braking. For overspeed, current limit stop is provided. Certain other faults such as hot bearing will permit rolling to the end of a coil but will prevent re-starting. Faults affecting the motor generator set may not only have to stop the mill but then trip the set. All the usual features are covered, e.g. over-voltage, overspeed (by both mechanical and electrical means), weak field, etc., and there is also protection in the regulating system control windings.

The control magnetic amplifiers are protected within their cubicles by miniature circuit breakers backed up by fuses on the main 400 cycle distribution panel.

A comprehensive alarm and annunciator system is supplied which indicates all the various occurrences which may need attention or may trip the mill in one way or another and this is grouped to indicate both the occurrence and the stand or drive on which it has taken place. In addition, fault locating switches are supplied for checking along circuits with a chain of interlocks so that faults can be clearly and rapidly located.

Observation of the performance of the mill as a whole can be made from a main supervisory panel; on the control gear in the basement these instruments are repeated on the boards where the various adjusting rheostats and resistors are mounted. The behaviour of the current in all regulating windings other than transient windings on the magnetic amplifiers is metered. In addition, monitoring meters with selector switches are supplied within the magnetic amplifiers for indication of internal circuit conditions.

From various control circuits and field circuits test terminals are brought out so that recorders can be inserted without having to break into permanent wiring.

MACHINE COOLING AND MAINTENANCE CONSIDERATIONS

There are three principal ways of cooling large machines:

(i) open self ventilated

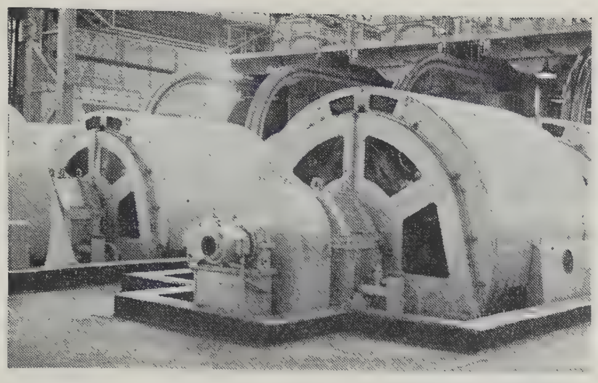
(ii) closed air circuit with commutator and brush gear open

(iii) closed air circuit with an air bleed-off over the commutator, which is also enclosed.

Self ventilated

The great advantage of this type of cooling is the good accessibility and visibility which leads to better maintenance and earlier indication of developing trouble. Commutators, brush gear, risers, interpoles, and commutating pole straps, etc., are visible and easy of access for blowing out and any remedial work that may be necessary. For the same reason, *in situ* repairs are both quicker and easier, and tend to be better done.

For these reasons, machines should always be open unless this is not permissible because of other considerations. For example, noise may be a limitation



10 *Drive side of four-stand tandem cold mill, showing motors with closed air circuit ventilation and enclosed commutators*

and also open type machines require a clean atmosphere in which to work.

The disadvantages of open machines are noise, heat release into the atmosphere, and susceptibility to damage by foreign matter entering the machine, such as oil vapour, conducting or abrasive dust, water, etc. The heat release may be serious in the case of large machines situated in motor rooms or other confined spaces since the whole of the machine losses are dissipated by heating the atmosphere in the room and may lead to a major ventilation problem.

Closed air circuit with open commutators

Where noise is an objection, it is necessary to enclose the machine itself but it may be possible to leave the commutator and brush gear open. While this arrangement is not quite so good as an open machine, at least those parts most subject to mechanical wear are visible and accessible, and the behaviour of the commutator usually gives an early indication of developing trouble.

Closed air circuit, including commutators

Totally enclosed machines are applicable where it is impracticable to use the first two alternatives, e.g. in unprotected areas such as mill bays. The lack of accessibility and visibility leads to a lower standard of maintenance and increases the time, and may reduce the quality, of *in situ* repairs.

There are substantial fan losses and space has to be found for heat exchangers which, in turn, require cooling water which increases the maintenance problem.

Much thought has been given to machine enclosures with a view to mitigating the disadvantages of totally enclosed machines. While improvement has been achieved, the ideal arrangement has not yet been devised, and there is scope for further development in this direction. Figure 10 shows the enclosure of a recently built machine. The aim has been to make each removable cover light enough to be handled by one man, yet strong enough to be serviceable. The method of fastening the covers to the machines does not rely on bolts or setscrews which are difficult to replace, and sometimes impossible if the covers have sprung.

Inspection windows are provided to give a good view of the commutators and brush gear and lights are fitted inside the enclosures.

Air filtration

While there are many types of filtration plants, they broadly fall into one, or a combination of the following four types:

(i) electrostatic precipitation
(ii) throw-away cotton wool or viscous fibre filters
(iii) oil wetted filters
(iv) water scrubbers.

Each has its own characteristics, but before deciding on any application the objective must be quite clear.

In both machine and motor room ventilation, it is not the particle size that is significant, but the total weight of solid matter that settles.

The smaller particle size has less chance of settling out than the larger ones, particularly in enclosed machines with high air velocity. For this reason blackness tests can be misleading.

The characteristics of the various groups are as follows:

Electrostatic precipitation

This is capable of removing particles of all sizes, even the smallest, but presents a maintenance problem (not to speak of a financial one). The design of the collector plates and the air velocity determine the dust collecting efficiency and these can be arranged to meet most requirements.

Build-up of dirt on the collector plates tends to cause spark-over. At the instant of spark-over the potential between the plates becomes zero. The built-up dirt at the point of spark-over may be disrupted and the disturbed dirt carried into the clean air emerging from the filter.

This effect can be reduced by oiling the collector plates after periodical hosing down but this adds to maintenance.

Where this type of filter is used, it is desirable to provide an alarm signal to the maintenance personnel to indicate if either the ionizers or collector plates have lost their potential, as otherwise the filter may be inoperative for long periods without this being known. Indicator lamps visible through small windows in the high-voltage supply units are not adequate for this purpose.

Throw-away type filters

There is much to be said for this type of filter, which can be arranged to give a good measure of cleaning. In dusty areas they may have to be replaced rather frequently, which adds to the cost. They are, however, cheap in first cost.

It is an advantage to phase a differential pressure gauge across the filter to give indication of the pressure drop through the filter, and a red line can be marked on the dial to indicate when the filter elements are due for changing. If this precaution is not taken, as the increase in dirt in the filter builds up the volume of air passing through the filter may be reduced below the safe limit.

Oil filters

A well-designed filter with a window velocity of 350/400 ft/min gives satisfactory filtration for most machine applications.

The type in which the filter elements are racked round by hand, so that each, in turn, lies in an oil bath, does not give adequate cleaning of the elements for many steelworks applications, and if this type is used it may be found necessary to lance the baskets out by steam from time to time. It is also difficult to

TABLE IV Main stand drive motors

Stand	Motors no.	hp each	hp total	Speed, rev/min
1	2	1 750	3 500	90/270
2	3	1 667	5 000	138/408
3	3	1 667	5 000	218/545
4	3	1 667	5 000	254/635
Reel	2	625	1 250	160/730

ensure that the elements are moved around regularly at the planned time. If this is not done, the filter elements become clogged with dirt and the window velocity increases to the point where oil is carried over, with serious consequences to machine insulation.

In some of the older installations, there was often barely adequate provision for cleaning the collected dirt out of the oil baths, which can be a very messy business.

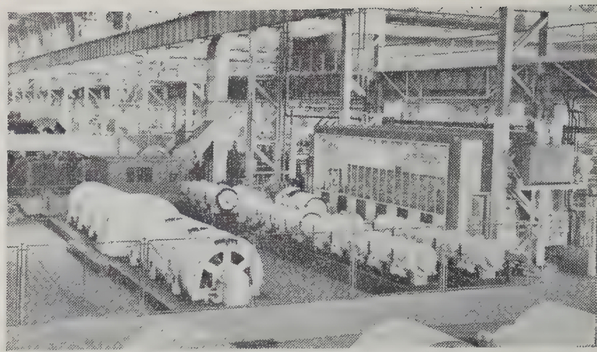
For these reasons, it is desirable that oil wetted filters for cleaning the cooling air of machines which have to run 24 hours a day, should be of the automatic type. These are so arranged that the elements are moved around automatically. Each dirty element is thoroughly washed out for a predetermined time by oil sprays under pressure, and the dirty oil finds its way to a sump where collected dirt is allowed to settle out. After a predetermined time, the oil is pumped to a clean oil tank automatically.

The dirty oil tank can be arranged at a distance from the filters in a position convenient for cleaning out the sludge and for its removal once a year, or as often as may be necessary.

Once again it is desirable to arrange alarms to indicate that the filter is working correctly, since it is even more difficult to ensure regular inspection and maintenance of equipment which may work satisfactorily for very long periods without attention.

Water scrubbers

Water scrubbers are sometimes used and have a filtration efficiency rather lower than the other types so far considered. They have the advantage, however, of



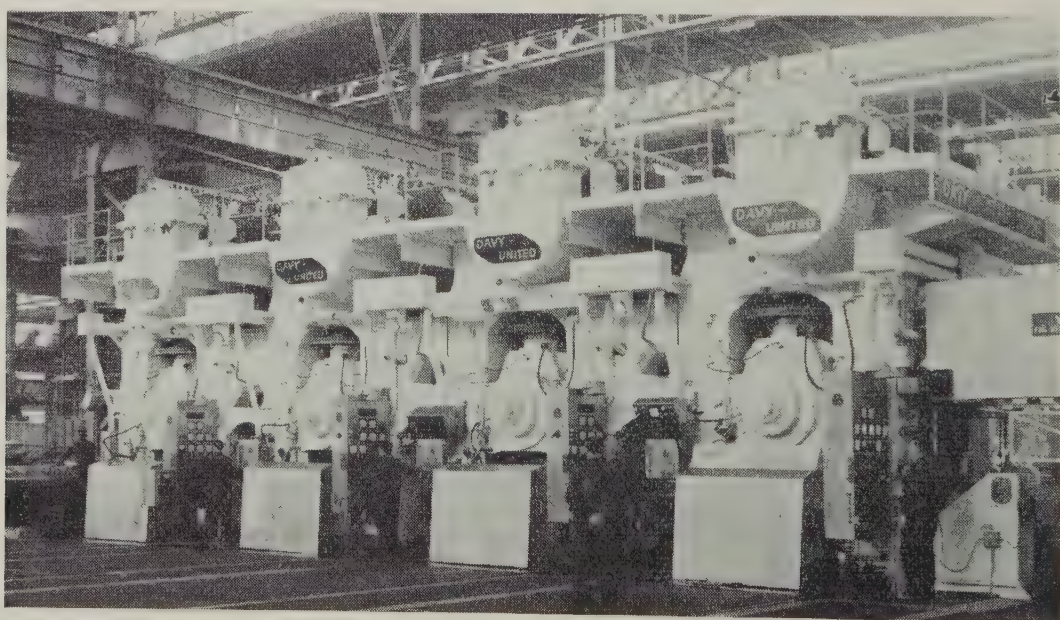
12 *Main and auxiliary MG sets in mill bay*

slightly cooling the incoming air and of increasing the humidity, which in certain conditions is beneficial to commutation.

It is necessary to ensure that moisture is not precipitated in cold machines, if the incoming air is hotter than the inside of the machines. Such a condition can arise, for example, if a machine has stood overnight and is then run up in the morning when the outside air temperature has risen. This can be safeguarded, however, by using a differential temperature gauge which will only allow the water sprays to be turned on when the temperature of the air leaving the machine is higher than the ingoing air temperature.

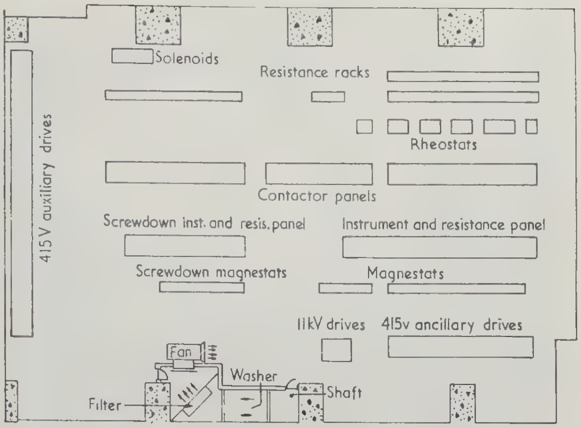
It is also possible, under certain climatic conditions, for precipitation to occur and for fog to be blown into the motor rooms, though the authors have not experienced this. The sprays can also freeze up in very cold weather and steam heating coils are used to overcome this latter difficulty but it is rather a mixed blessing and not always 100% effective.

For these reasons, it is quite a good arrangement to back up a water scrubber with a throw-away filter, so that the air is cleaned even though the water sprays are turned off. Owing to the cleaning of the air by the scrubbers for the majority of the time, the life of the throw-away filters is long.



11 *Operating side of four-stand tandem cold mill*

13 *Control wiring terminal boxes beneath stands*



14 *Layout of control basement for four-stand tandem cold mill*

The only other point to watch is the possible rusting of unprotected steel parts owing to the somewhat high relative humidity. The authors have had experience of such an installation, which has worked very satisfactorily for over 18 months and none of these difficulties has so far been encountered.

DESCRIPTION OF THE FOUR-STAND TANDEM COLD MILL AT ABBEY WORKS, THE STEEL COMPANY OF WALES LIMITED

Reference has already been made to a 56in four-stand tandem steel mill commissioned in the middle of 1959, and it may be of interest to describe some of the features of this installation.

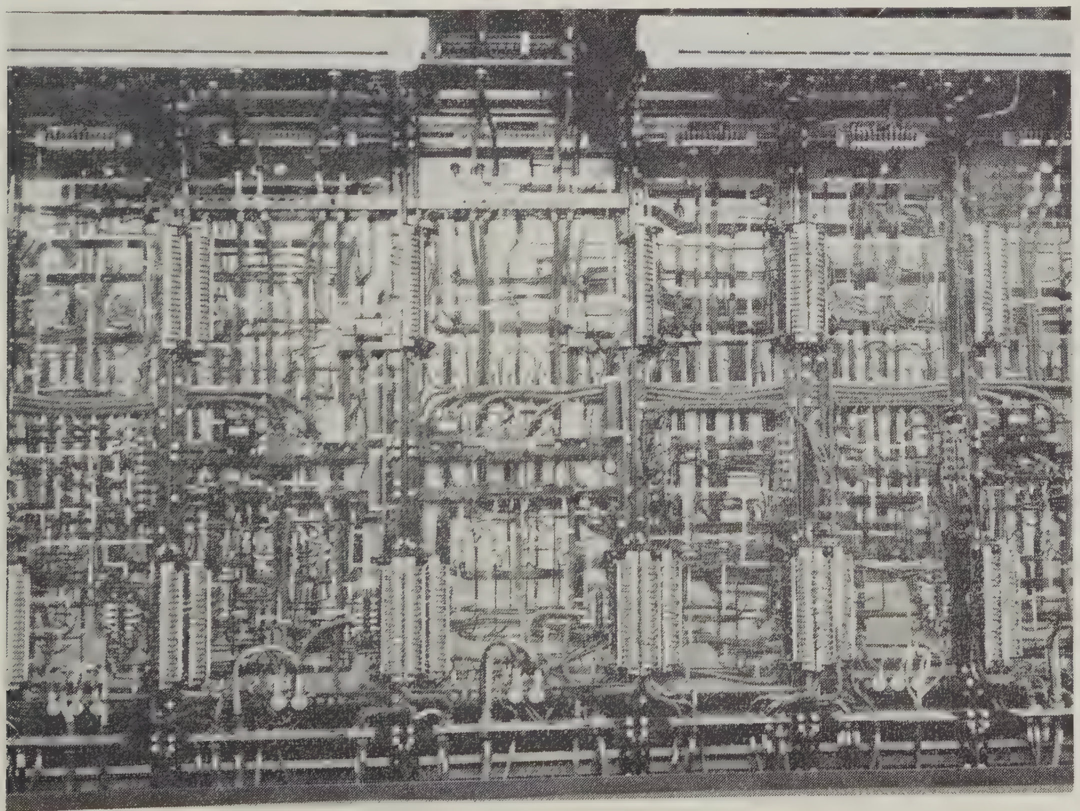
The main power is supplied by two MG sets each of which is driven by an 11 600 hp synchronous motor. There are six identical 1400 kW 600 V dc generators in each set.

No.1 MG set supplies stands 1 and 2 and the reel and no.2 supplies stands 3 and 4.

The main stand drive motors are shown in Table IV.

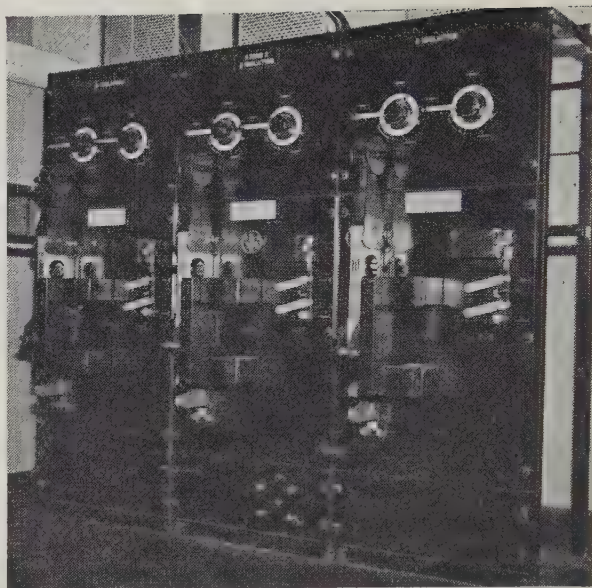
Figure 11 shows the operating side of the mill. Figure 12 shows one of the main MG sets and also the auxiliary MG sets and the supervisory panel. All the rotating machines are in the mill bay and are, therefore, totally enclosed.

Figure 10 shows a standardized gearbox developed for mill drives which has two output shafts for auxiliaries such as tachogenerators and overspeed devices. This can have a ratio adjustable from 4–1 to 1–4 in steps of a half to match any drive requirements and is



15 *Back of panel wiring, showing terminal arrangements*

16 Vis-à-vis *arrangement of control panels in basement*



17 *Stand motor isolating panel in basement*

designed to withstand the heaviest shocks expected from a rolling mill drive.

The supervisory control panels, from which the sets are started up and shut down, are situated in a room giving a view of the machines being controlled. Each circuit is monitored by indicating meters enabling the controller to see what is happening.

All stand control wiring is taken to the basement via a group of 4–6in conduits on each stand which were seen in Fig.10 and the wiring is terminated in large terminal boxes under the stands as shown in Fig.13. This arrangement keeps the wiring away from the millstands in a position safe from damage and where it does not become contaminated with soluble oil, etc. This also proved of the greatest value during erection and commissioning which, as usual, had to be done against time. The cabling from the control panels, which are situated in the basement, was completed to the terminal boxes and checked before the erection of the mill stands had been completed.

The layout of the control gear is as shown in Fig.14. All interconnectors between panels are run in trenches in the floor and all outgoing cables in trays above the boards, the terminal strips on the control panels being disposed appropriately. This gives a neat layout as can be seen in Fig.15. Insulated flexible cables are used for back of panel wiring in place of copper straps. This gives easier access for testing and cleaning and is far safer.

Figure 16 shows the control panels and setting up and metering panels. These are arranged facing one another, so that the operation of the control gear and meters monitoring each circuit can be seen while adjustments are being made. This arrangement proved extremely helpful and undoubtedly assisted in keeping the commissioning time to a minimum.

In a high production unit such as this, the value of throughput lost owing to a breakdown can be very substantial. For this reason, it was decided to make provision for the isolation of any motor with its associated generator, by means of links, and similarly to switch out their field circuits, so that in the event of trouble the faulty machine can be cut out in a matter of minutes, and so allow the mill to continue to roll on reduced power. Investigations and remedial work can then be undertaken at a time chosen to have the least effect on production. Figure 17 shows the arrangement of one of these link boards.

ACKNOWLEDGMENTS

In conclusion the authors wish to acknowledge the assistance of a number of their respective colleagues in the preparation of the details of this paper and to thank the directors of The Steel Company of Wales Ltd, and the executive of the heavy plant division of Associated Electrical Industries Ltd, for permission to publish it.

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DISCUSSION ON PAPERS

Discussion at meetings
Written contributions

Report of the Forty-second Engineers Group Meeting

The forty-second meeting of the Iron and Steel Engineers Group of The Iron and Steel Institute was held in London at the offices of the Institute, 4 Grosvenor Gardens, SW1, on Wednesday and Thursday, 1 and 2 March 1961. Mr W. A. Johnson (The United Steel Companies Limited) was in the Chair. Discussions at the three sessions are given below.

Discussion on universal beam and heavy structural mill at Lackenby

SESSION I Mechanical features

At session 1 the first part of the paper **'The universal beam and heavy structural mill at the Lackenby works of Dorman Long (Steel) Ltd'**, by *A. P. Clark* and *R. E. Kenderdine* (this issue, pp.343–360), illustrating the mechanical features, was presented by Mr Clark and discussed.

The **Chairman**, introducing Mr Clark, said: One of the most interesting and important developments in the UK since the war has been the construction at Lackenby of a rolling mill designed specifically to produce an entirely new range of beam and column sections. Structural steel designers have mostly been working with the normal standard BS.4 range of sections. Thus the economy in weight and workmanship which a good range of broad flange beams can provide will be much appreciated; current competition from alternative methods of construction has shown that steel construction must be competitive both at home and abroad. The production of universal beams was considered by Dorman Long before the war; subsequent difficulties caused by the war prevented a start being made until about 1953 and the first sections came off the Lackenby mill early in 1958. This mill follows fundamentally the process, developed by Grey at Differdange in the early years of the century, for beam rolling in a four-roll mill. Later, modifications were made to that unit, the taper on the flange being progressively reduced. On the continent beam and column sections are also rolled with near-parallel flanges on a modified two-high reversing mill, and there is one instance in the UK. A section in conventional roll passes is produced and then the rolling taper is removed in a four-roll or universal pass.

These mills, in respect of flange width and flange thickness, are limited by considerations of economical production. The Lackenby mill is unique in the UK for its range; however, other companies shortly expect to have similar facilities. Mr Clark's subject is the mechanical arrangement of this mill for producing universal beams in heavy structural sections.

Mr **Clark** then presented his part of the paper.

Mr **R. Stewartson** (Guest Keen and Nettlefold (South Wales) Ltd): The paper provides a very clear, concise, and explicit description of the new plant. Dorman Long should be complimented on their courage and their faith in the future of British industry in undertaking the tremendous expenditure on this very large project. Both civil and mechanical engineers in the UK have felt the benefit of the wide range of new sections produced by the mill; they also see the wisdom of the decision to install it, while the appreciation of the section rolling industry is shown by their published expansion plans which although of a smaller scale, follow the Lackenby lead. How is the market developing for these large wide-flange beams? In structural applications the broad-flange beams, and particularly the columns, compete with reinforced concrete; my own experience is largely related to small mills producing the steel bars and rods which are eventually used on concrete reinforcement, and therefore to some extent I am representing a competitor of the Lackenby broad-flange beam mill. As an engineer, however, I have no doubt that these new sections are of great value in machine weldments, especially for steelworks equipment, not only because of the parallel flanges which greatly reduce the cutting and welding required, but also owing to their very weight, which makes them so suitable for such applications, and saves so much cutting and welding of plate sections. An up-to-date appraisal, from the authors, of the prospects of the expanding use of these sections in both mechanical and civil work, would be most welcome.

The design and manufacture of this project are not entirely British, but undoubtedly a preponderance of design and workmanship has emanated from the UK, to form a national achievement in which we can take great pride. Equally, there is no doubt that Dorman Long have been very wise to go abroad for those sections of the plant where many years experience in design and operation are available, and where the UK was entering new ground. This plant combines both the best of UK engineering and the experience and knowledge of plant capacity gained by overseas manufacturers, lack of which might otherwise have delayed a successful operation.

The very wide range of sections which this mill produces is impressive. A range 17–426 lb/ft is almost unthinkable, and yet this mill can cover it. The versatility of this plant and the arrangements described in the paper for changing sections rapidly are of great interest. Would Mr Clark enlarge on the methods of roll changing and the way in which the plant is kept operating at high efficiency when producing a range as wide as this? A little more information on how the billet mill fits into the scheme would be useful. Does it roll while the beam mill is rolling the lighter range of sections for which the blooming mill rolls also have holes available for billet blooms? Does it operate while the section mill is roll changing? Is there a sufficient supply of blooms in the reheating furnace to keep the billet mill working while rolls are being changed in the universal mill? How does Mr Clark organize the mill operating crews so as to make use of them productively when sections of the plant are down for changing?

With regard to the detailed plant, the illustrations show that the ingot-weighing device is mounted underneath the roller tables. Previous installations I have seen make use of an overhead structure, presumably to avoid difficulties of dropping scale; but such structures may have suffered somewhat from the heat rising from the ingots themselves. Do Dorman Long make use of load cells in this ingot weighing device, and have they had any trouble with scale and heat?

It was interesting to see that in the blooming mill itself

there is no provision for automatic screwdown or programming of the mill, whereas this is the case on the universal stands. There might be some advantage in providing this equipment on the blooming mill, if only to provide a reliably uniformly preformed bloom for the universal mill. How many operators are there on the blooming mill?

On the bloom reheating furnace an overhead crane is used to transfer the hot blooms from the furnace itself to the breakdown mill table. Why was this used rather than conventional skids, and was the crane completely automatic or remotely controlled by an operator?

Turning to the universal mill itself, I should like to know what sort of reduction one can obtain in a single pass in this type of mill, and whether the amount of this reduction is at all affected by the scuffing action which must occur between the inside face of the flanges and the side face of the horizontal roll. Does such scuffing in any way affect the amount of draughting which can be taken in this particular mill? Why has the edger, which is relatively low-powered by 2700 hp, been given a twin drive, while in the main stand itself there is only a single motor, of twin armature?

The cooling bed arrangements provide an admirable way of maintaining a high production rate and at the same time a good yield. With a section of 400 lb/ft, even a few inches of wastage represents an important loss of material. The stopper gear for the hot saw is particularly well devised. I noticed that at the ingoing side of the first cooling bed, turn-up gear is used; apparently this has a very gentle action and does not distort the section when turning on to the flanges, but when a semi-cold section leaves the bed it is just allowed to drop down. With the heavy sections might this not give rise to very heavy shocks on the bed and table structure, with possibly some chance of distorting the sections themselves?

Finally, I think one of the interesting things in this mill, which is rather lightly touched upon in the paper, is the use of floor-operated vehicles for handling. A side lift truck in the mill loading bay is referred to. This is a development which is going to grow in importance and popularity. Has the company given consideration to the use of straddle carriers, which might require less gangway space, and what are the authors' feelings on the prospects of expanding the use of this type of equipment in a rolling mill of this nature, for the handling of billets and blooms and the inter-works transfer of such materials? Dump trucks in some works are used for scrap and scale removal. At our works we have two railway wagons standing a whole week at the scale pit in anticipation of the weekend clean-out. A dump truck might have been a very quick, simple, and versatile means of dealing with that problem. Would such vehicles be useful for maintenance purposes for handling smaller items of mill tackle during roll changes when the main mill crane is fully occupied?

Mr **Clark,** in reply: The development of the market for universal beams is a rather difficult question for an engineer to answer. When the mill was completed we announced that rollings would begin in July 1958. Until we could announce that rollings had begun, designers could not consider using these beams, and even after this point, there was bound to be the interim period between design and the permission to place orders. Meanwhile, in 1959 the strike in the USA gave us some overseas orders, and since then we have found that more and more designers are turning to the use of universal rather than ordinary beams, not only in structural work, but also in mechanical frames and bedplates. So, while the market is capable of considerably greater development, it is itself a growing one, and the mill will produce all and more than we expected.

Mr Stewartson mentioned that we went abroad for the main stands; when we decided to build this mill the only modern experience on the rolling of these beams of American sections was in the hands of the Americans themselves, and so we had no choice but to go there for the main machinery. However, the blooming mill, and, apart from the hot saws and the measuring gear, the whole of the cooling banks and the handling and straightening machinery were British, except that the very big straightening presses were of American design. No firm in this country had made a press of the required size, and we could not wait for a design to be developed or be sure that such development would be completely successful.

The method of roll changing is quite simple and straightforward. For a complete change, there are four stands, two main and two edging, to be lifted out and four stands to be lifted in. There are two cranes, one of 275 tons which is capable of lifting a main stand, complete with rolls, and a 180-ton crane, which can lift an edging stand. Before lifting a stand, all the electric cables are disconnected at a plug box which has been provided near the top of the stand and the loose cable ends are left hanging from a swinging gallows. Meanwhile, all the oil and water pipes are disconnected. These are provided with flexible sections and quick-release self-sealing couplings. The spindles are retractable by hydraulic power and are withdrawn from the roll ends, complete with the roll adaptors, which, when free of the rolls, rest in specially designed extensions to the spindle support cradles. As each stand is ready the crane driver brings in his hook and without assistance engages the two lifting shackles. Each stand is taken in turn to the roll-change beds and a new stand is brought back on the return journey.

Meanwhile, at the blooming mill, a pair of new rolls has already been placed on the dual roll change rig, ready for the change. When the mill stops work the top roll chocks are disconnected from the hangers, to rest on the bottom roll chocks. The whole roll assembly is pulled out of the stand, traversed to bring the new rolls in line, and the new rolls pushed in. When the rolls are almost ready for engagement with the spindles, the operator on the roll change can control the movement from a point adjacent to the spindles. As he brings in the rolls at a creeping speed he can also move the spindles at creeping speed up or down, and rotate them if necessary.

The billet mill was intended to make use of the difference in the capacities of blooming and universal mills. Provision has been made in a number of the blooming mill rolls for rolling rectangular blooms in addition to shaped blooms. For instance, at a roll change, the blooming mill has about 1 h of free time because the universal mills take much longer to change and be ready for the next section. Another case of being able to roll a few blooms other than shapes is when the shaped blooms must go through the furnace. A stock of these shapes can be built up on the furnace feed bank and for about 20 min the blooming mill can then roll blooms, which are transferred straight to the breakdown mill and billet mill. It is for this purpose that the overhead crane is used. The rectangular bloom occupies the roller tables and skids to the breakdown mill and the shaped bloom must be transported overhead from the furnace to the universal roughing mill run-in table. The crane is semi-automatic. Its waiting position is in front of the furnace, with the fingers below the furnace skid rails. When a bloom is pushed out of the furnace, the operator in the breakdown mill pulpit presses a button, the fingers rise, and as soon as they are clear of the skids the crane automatically moves across and waits at the run-in roller table until a second button is pressed. The fingers then lower, and the bloom moves away on the roller table. As soon as it is clear of the fingers, they automatically rise, the crane moves back to its former waiting position at the furnace, and lowers its fingers below the skid level.

The mill operating crews, during a roll change, are fully occupied in assisting the roll change crews. Normally, they have first to move the ingoing and outgoing traversing tables out of the way so that ample space is available for lifting the stands. They then operate the screws and move down to control desks on the mill floor where the spindles can be hydraulically retracted to bring them clear of the rolls.

Regarding the placing of the ingot weighing scale below the roller table, rather than installing an overhead weighing machine we decided that the mill operators must have a completely clear view of the soaking pits, and the heaters of the

mill. That is why we asked for the weighing machine to be down below. We have had trouble with mill scale, causing inaccuracy, and we have a scheme going through at the moment for weighing the ingots, after they are stripped, as we do not want the weight of individual ingots but only of a week's make of ingots. We propose to weigh the ingots as they go through from the stripper bay to the soaking pit bay, and the steelplant management say that this will be satisfactory. The proposed method of weighing will be by means of load cells. While these are not guaranteed to be exactly accurate, they do retain their accuracy; most of our heavy weighing machines lose their accuracy after quite a short time.

Pre-set screw-down on the blooming mill was not thought to be necessary. There are two operators, with ample time to do all that is required. However, it is possible that within a year or two we may have automatic screw-down on the blooming mill, for the shaped blooms, where there are a number of blooms all similar. The draughting on the universal mill is not affected by the possibility of scuffing. Occasionally marks can be seen on the inner flange of the deeper beams which show that they have been worked between rotating rolls.

The reason for a turn-up gear on the hot side of the cooling bank and a knock-down at the cold side is that while the beams are hot they must be turned and placed reasonably gently or they will be damaged. By the time they are at the cold side, they are strong enough to be knocked down without the slightest fear of distortion. The temperature at the cold side of the primary bank is somewhere around 250° to 400°C, and at this temperature the steel is strong enough to stand some rough usage.

On the general use of floor trucks in the loading bay, side lift trucks were put in after the plant started. It was found, owing to orders for abroad having to wait for ships, and to a certain number of damaged sections which had to be put aside to be replaced or dressed, that many orders could not be loaded straight from the transfer cars into wagons, and the loading bay became full of beams lying on the floor. Side lift trucks were then used, so that beams could be taken right out of the bay, and returned when there was a load to be made up. The side lift truck was chosen as it is the only vehicle capable of lifting direct from a transfer car. A straddle carrier would not serve the same purpose, as it could only lift off the floor if the bars had been placed there. These trucks are very expensive, they are not very fast, and maintenance is quite high. For an operation which is repeated over and over again, it is better to design a piece of real steelworks machinery for the purpose. The real advantage of floor trucks is that they can travel and carry beams anywhere, right outside the building if necessary, and bring them back. We are using floor trucks to a greater and greater extent, not only in the mill but in other parts of the works. We are using side lift trucks, straddle carriers, and a number of fork lifts; those are the three principal ones, dump trucks are used for various purposes.

The **Chairman**: There is one outstanding point: why is the edging stand driven by twin motors? Would Mr Higson care to have a word on that?

Mr **J. Higson** (Dorman Long (Steel) Ltd): The decision to drive the main stand by means of a double armature motor with pinion box was made to avoid any possibility of 'turn-up' or 'turn-down'.

At the time the decision had to be taken on the motors, twin drives had only been used on blooming mills. It was felt that a twin drive could be used for the edger as this stand has only a small amount of work to do compared with the main stand.

Dr **H. R. Mills** (BISRA): My first question is in connexion with the pre-heaters for the soaking pit air and gas supplies. These pre-heaters are of a metal tubular kind and therefore the tubes themselves must run at a high temperature. What experience have Dorman Long had with these pre-heaters; have they in fact found that the life of this tube is reasonable, or have many repairs or replacements been necessary?

How is the use of this high air and gas pre-heat temperature reflected in the fuel consumption for the pits? Has Mr Clark any figure for the therms/ton of steel heated which might allow us to judge how effective this was? I realize also that this must depend on the extent to which cold ingots are put into these pits; I know of no other means of heating cold ingots but I should welcome correction. At the same time as he quotes the therms/ton, therefore, can he give any idea of the proportion of ingots heated from cold? The pits are fired mainly with blast-furnace gas; if ingots are heated from cold, are any steps taken to enrich this gas for heating the cold ingots?

What means are there at the hot saw for correcting the variations in temperature? The paper suggests there is a means of adjustment if the temperature varies from normal, to allow for greater or less shrinkage than was envisaged. If this is only a means of correcting for variations in temperature, presumably then it must have incorporated some means of allowing for the normal shrinkage. Does this mean that the 10 ft length between the stops is not 10 ft but some corrected or false value which allows for shrinkage? Is this scale also applied to the normal movement of the stops? Even if the temperature were the same for all the pieces rolled I should have expected some difference in the amount of shrinkage. What accuracy is really achieved, i.e. how far does the cold length in fact vary from what was anticipated?

With regard to the side lift trucks, Mr Clark has already, in reply to Mr Stewartson, explained some things; however, is their experience to date such that they can say whether this kind of machine is what they would choose now if they were faced with the same problem again?

Mr **Clark,** in reply: Our operating experience up to now on the recuperators has been that over a running period of $3\frac{1}{2}$ years, and allowing time for repairs to be made, there has been no serious complaint.

On the fuel consumption, the proportion of cold ingots has at times been very variable, and the fuel consumption naturally varied with this proportion, though an important factor in fuel consumption has proved to be the actual throughput.

Average figures, for 10–20% cold ingots, are 14 to 16 therms/ton. The gas can be enriched when heating from cold by adding coke-oven gas. The calorific value is increased while the heating is taking place to about 115 Btu/ft^3.

Regarding the hot saw temperature correction, the stopper heads on the measuring gauge are nominally at 10 ft centres. The actual centres are 10 ft $1\frac{3}{8}$in, which allows for cooling from the average expected temperature down to atmospheric temperature. If a bar is seen to be colder than normal a second pilot motor can make a further adjustment of the carriage position. That is approximate only as there is no measurement of temperature, and the operator relies on his experience. Actually, the usual cutting allowance is 1in on either side of the normal, and it is found that the built-in shrinkage allowance, unless the bar is very cold, is quite accurate enough for all ordinary purposes.

On the question of side lift trucks, they are put in for a particular purpose, to move material without using overhead cranes, which are unable to do much long travelling without causing difficulties for each other. The side lift truck can travel under the crane, and has the same effect as a roller table on the floor.

For this particular purpose the side lift truck has proved quite successful, and if faced with that same problem we would probably adopt the same solution.

Mr **J. McLauchlan** (Appleby-Frodingham Steel Company): In the paper one roller straightener and four gag presses are mentioned. I was under the impression that there were two straighteners. There are two in Fig.1 of the paper. If there is only one, is it capable of handling the production that is expected to pass through it? There are certain limitations on the size of the beams which can be straightened and I should welcome an indication of the range.

Elsewhere, certainly in the USA, the rolls that give the most trouble in four-roll stands are the vertical rolls; would you agree that there is a similar state of affairs at Dorman Long, if so, is the trouble experienced on these vertical rolls to be attributed to the roll or the bearings?

On the horizontal rolls, fabric bearings have been used. There is the obvious advantage of obtaining a larged faced vertical roll on that account, but if the job was repeated would you consider the use of roller bearings instead of fabric?

Mr **Clark,** in reply: The layout plan certainly shows four gag presses, and there is one roller straightening machine and space for a second. When we laid out the plant we were not quite certain whether we should require one or two of these machines. We therefore installed one machine, but we put in traversing carriages for two. Up to the present one machine deals with its work quite adequately. It is a 53in seven-roll machine. It was intended to straighten the largest British Standard beam, 24in × 7½in, and also any of the broad flange range up to roughly that size. Up to now we have straightened beams as small as 6in × 6in on it. We have also straightened all beams with flanges up to 8in wide, and the 24in × 9in universal beam. The spindles are probably not long enough to take a deeper beam, and we have certainly never tried to straighten anything above this size.

With regard to the vertical rolls, we have had trouble with them, in two forms. The first was that some of the rolls appeared slightly eccentric, the other that the outer races of the bearings themselves appeared to be expanding. The original bearings were of an old design, which, we were assured by the operators on other mills, were perfectly satisfactory and had been running without trouble for a number of years. They were not satisfactory in our mill, and we have since found out that this type of bearing has been superseded. We have now re-designed the bearing arrangement, at the same time trying to improve the end seals, because we found that the original seals allowed water to enter and grease to escape. The seals, as re-designed, we hope will cure these troubles. The latest races fit in the rolls much tighter, and apparently are now working well. With regard to eccentricity, these rolls are turned on an ordinary roll lathe, mounted on a mandrel, supported by grooves cut in the roll ends. On setting up the rolls on the lathe, it was found that the grooves had been damaged by carelessness, and that the rolls were consequently being turned eccentric.

In reply to the question on fabric bearings, our difficulty was that in order to get the vertical roll between two necks of the horizontal rolls there was just not room for anything else but a half bearing. To get a roller bearing chock on the neck of the horizontal roll, and a vertical roll in between the two necks, the vertical roll would have to be very much narrower than we have, which has to be wide enough to roll our largest beams and columns. Our widest flange is just under 17in and the vertical roll has a face 18½in wide. That was the problem, and the only way we could see of solving it was to use fabric bearings.

Mr **McLaughlan:** Would you choose the roll fabric again? Are the fabrics quite satisfactory?

Mr **Clark,** in reply: Up to now we have found that the fabric bearings give a very good life indeed; they are quite easy to replace and very easy to dismantle in roll changing. There has been no neck damage due to scale or to scoring, and given the same circumstances again we would probably again use fabric bearings. On the other hand, that is not to say that in a blooming mill, with a roll change say once every three weeks, there is as good a case to be made for fabric bearings. In our case we had already decided on fabric bearings at the universal mills with the accompanying water circulating and filtering installation, and therefore we repeated these bearings in the blooming mill. In an independent blooming or slabbing mill we may think differently.

The **Chairman:** In many people's minds there still are mixed feelings in regard to the use of fabric bearings, and in some circles it has been said that they are more satisfactory on smaller mills and less satisfactory on larger ones. I recollect that the Guest Keen Iron and Steel Co. have been using fabric bearings on their 40in reversing mill for over 20 years. There is also other evidence that fabric bearings are satisfactory on large mills. Dorman Long must have had considerable confidence in the concept, in that all their horizontal rolls are so mounted. The term 'fabric bearings' is a generic one, but there are manifold compositions. May we ask Mr Clark if they have tried more than one type, without particularly asking which type he finds best?

Mr **Clark,** in reply: I am not certain whether more than one make has been tried but Mr Raisbeck, our works manager, could possibly answer that.

Mr **R. A. Raisbeck** (Dorman Long (Steel) Ltd): We did have some trouble due to fabric failures in the summer of 1959. This was largely attributed to the deterioration of the roll necks. After re-grinding the necks and making other safeguards to ensure that when out of the mill the necks are properly greased, we obtained reasonably satisfactory life from the bearing fabric. At the same time we changed the type and increased the supply of grease to the chocks, and before changing the mill the operators are required to turn the rolls slowly for a few minutes with the roll neck water turned off. This ensures that a reasonable coating of grease remains on the roll necks until such time as they are stripped down and passed into the roll lathe shop.

We obtain all our fabric bearings from two well-known manufacturers and we have found both equally satisfactory.

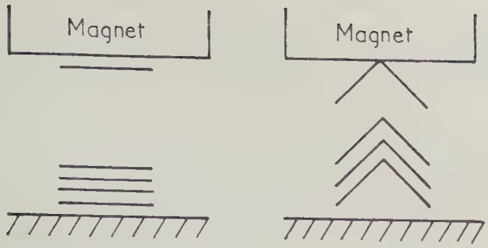
Commander **J. I. T. Green** (BISRA): I have two points. The first relates to the 52in blooming mill, concerning the screw-down gear and the roller table bearings. The troubles relating to jamming of mill screws led us in BISRA, at the request of a member firm, to devise a hydraulic jammer in order to avoid, on these occasions, the horrible business of burning out the breaker bars, and I was delighted to read that in this mill they are using a hydraulic motor on the screw drive. Is this new? If so it seems to me an excellent solution, which may lead to the adoption of the hydraulic motors generally for screw drive.

Secondly, with regard to the hot saws, we noticed just now that the yardstick is keeping pace with the mill production, which can be over 200 tons/h. Apart from that being three times the mean production, which one would naturally accept, it seems to us that the tonnage is not the yardstick, because this would increase with the larger sections which do not have to be cut so often. What is the proper yardstick?

Mr **Clark,** in reply: With regard to the question of screw-down jamming, we are not using a hydraulic motor, but hydraulically-operated screw relieving gear which turns the shaft of the screw drive. It has proved successful on the whole, as a very high torque is exerted on a normally high-speed shaft. We have in another of our mills a screw-relieving gear with a ratchet-wheel and a pair of pawls on a lever which can be raised by means of the overhead crane.

On the subject of the speed of hot sawing, the figure of over 200 tons/h, is not the only yardstick for the sawing rate. While generally the higher tonnage rates are achieved with the heavier sections, which, by the way, take much longer to cut, we have had 200 tons/h with a 24in × 7½in British Standard beam at about 100 lb/ft. Generally, the fastest rolling in terms of ft/min is on the lighter bars, and it is these that to a large extent govern the rate of sawing because there are more cuts to be made for each ton of material. The 200 tons/h should be treated only as a measure of the size of the problem.

Mr **R. B. Atkin** (Appleby-Frodingham Steel Company): I should like to follow up the queries that have been raised on



A *A magnetic stacker*

hot sawing. These saws are required to cut a wide range of section: different web and flange thicknesses, and different size sections. Does the saw speed remain constant? Is the blade thickness the same throughout these sections, or is it necessary to blade-change to suit the sections that are being cut? I should like to know any information available on blade life; whether they are tipped blades, and any other sort of troubles experienced in sawing.

Turning to the universal mill: no mention has been made in the paper about the difficulties of maintenance on the bottom screw-down gear on the universal beam mill. That gear is probably susceptible to the ingress of water and scale; have Dorman Long had any difficulties, and what measures were adopted to overcome them?

On the blooming mill, I notice that Dorman Long are using independent motor drives for six rollers on each side of the mill. There is a case for saying that one can point-load. One can get a badly-shaped ingot which could point-load a roller at a particular point and result in stalling with independent driven motors. Has this sort of trouble been experienced?

Mr **Clark,** in reply: The hot saw speed when the blade is new was designed to be just over 21 000 ft/min. When cutting, the motor slows down by roughly 8%, so that the tooth speed is about 19 500 ft/min. Various blade thicknesses have been tried, between the original $\frac{9}{16}$in and the thinnest, $\frac{3}{8}$in. Blade life has not been as good as we would like, although a number of changes have been made in the tooth pitch, toothshape, and blade thickness, none of them with complete success. The blade life is still very short. The most successful thing we have done up to now is swaging of the teeth by heating the rim of the blade as it slowly rotates, and applying pressure to the heated surface. The rim is slightly thickened and gives a slight side clearance in the cut. Much of our sawing trouble is due to the fact that as the bar is being cut it nips the blade sideways; in some cases you can actually see the bar becoming hotter as the blade goes through.

We have had to make repairs on the bottom screws, and they are certainly not easy to get at. On the other hand, the advantages of having bottom screws outweigh the disadvantages. The rolls can easily be set at the proper height to suit the beam being rolled and, after all, the purpose of the mill is to roll beams and not to be maintained successfully.

Turning to the comment on independent rollers at the blooming mill, only the housing rollers are individually driven. The next four at each side are independent of the main tables. The tendency in heavy mills at the time we ordered this mill, which, of course, was seven years ago, was to install independent rollers rather than rollers with bevel gearing. If we were ordering the mill today, we would probably give each roller its own motor. The size of motor required is not exceptional. It must accelerate the roller, and in addition give enough torque to overcome the friction between the roller and the bloom or the ingot which is on it. On modern prices in the UK, it is proving to be an economic proposition to drive each roller independently, even these very big ones, and independent drives certainly get rid of all the maintenance inevitable with bevel gearing.

Mr **Atkin**: I am all in favour of reducing the amount of gearing to the minimum as Mr Clark suggests. We have large installations with independent motored rollers which are generally satisfactory. In certain locations however (i.e. slab receiving tables) we have experienced stalling conditions with independent motored rollers due to badly shaped slabs point-loading the roller.

Where such conditions are likely to be encountered we consider there is an advantage in group drives rather than independent roller drives.

Mr **E. F. Farrington** (Appleby-Frodingham Steel Company): If British Standard sections had not been on the original specification for this mill would you roll-change by change stands or *in situ*? In view of the width of the range of production of universal sections, if British Standards had not dictated change stands, or if you dropped British Standard sections, would you roll-change *in situ* or still insist on change stands for the universal beam mill?

If British Standard sections had not formed part of the original specification for the mill and the size range of universal sections had been less, would you still have employed change stands, or relied on conventional methods of roll-changing *in situ*?

Mr **Clark,** in reply: We would change the stands in any case. We have a much older mill in our company with two 34in stands which have always been changed by lifting out. In this mill, even if we had not wanted to be able to change from one type of stand to another, we would still have used the same method.

The **Chairman:** Could I ask an ingenuous question here? I am not familiar with the details. These 275 tons do not hold themselves down solely by gravity, I am quite sure. Do you drop them on to heavy foundation bolts and provide some ingenious mechanism for quick securement to the foundations?

Mr **Clark:** The stands actually rest on their own cast steel bedplates, and have holding-down bolts, but in any case a stand of that weight will remain quite firm and stable without any bolts at all. Whether they tighten up these holding-down bolts I do not know, but there is one mill in America where they do not bother to use them.

Mr **G. H. Billings** (Shelton Iron and Steel Co. Ltd): What means are you adopting for the stacking of angles and flats for dispatch? It is reasonably easy to stack joists by magnetic means.

One of the difficulties of using a magnetic stacker on say thin flats and angles is the magnetic field disturbing the already partly-formed stack when lowering a piece into position; this is illustrated in Fig. *A*.

Mr **Clark,** in reply: We have rolled angles in this mill, but not flats. Angles have been stacked, quite successfully, using the magnets on the piling cranes, with which we can stack them exactly as we stack the beams.

The **Chairman:** Does that matter?

Mr **Billings:** The BTC in our area demand that this type of material be stacked in this manner for transit, and to facilitate ease of handling during unloading.

Mr **J. A. Kilby** (Colvilles Limited): The market in universal beams in this country has not developed as quickly as it might have done because so far there has been only one supplier in the UK and the designer has hesitated to place himself entirely in the hands of the one supplier. Soon a further four mills will be operating in the UK and this will give the customer the assurance that the supply of these sections will be readily available and demand should build up substantially from the present figure.

I should like to ask Mr Clark whether any consideration has been given to the production of the new IPE lightweight

sections with parallel flanges and whether he visualizes, having in mind export possibilities, that they might roll this new type of section in the near future.

To what extent are universal beams being rolled directly from the ingot without intermediate reheating, and in cases where intermediate reheating is resorted to, is this to facilitate the rolling of the section or is the furnace intended to act as a buffer between the blooming and section mills?

Mr **Clark,** in reply: We have given consideration to the production of lightweight sections in our company, but whether or when we shall do it I do not know. On the question of direct rolling, there are only five of the lighter beams which go through the furnace. All the remainder are direct rolled straight through from the blooming mill, to the roughing and finishing mills. These five which are reheated are the smallest ones which do not retain enough heat to roll direct. But in actual fact we do take advantage of the fact with these small sections, that while they are going through the furnace the blooming mill can roll blooms which go direct to the breakdown mill and the billet mill, so that while this is happening we are actually doing two jobs at the same time.

Mr **R. Green** (The United Steel Companies Ltd): It is refreshing to see the novel stop and measure gear associated with the saw which avoids the rather cumbersome and slow-moving lead screw. The new system seems much faster, but how is the momentum of the bar taken up as the bar crashes against the stop? The paper suggests that the length selection is locked when the stopper comes down, but does this mean that the control system is locked or that the moving carriage is somehow physically locked to the base? If the carriage is not locked to the base I presume that the hydraulics must take the impact and if they do they must yield a little and move away under the impact to give a length greater than the pre-selected value. If this is so, does the carriage tend to come back under control and can it move the heavy rolled bar back with it? Could the author clarify the operation and indicate how the momentum of the bar might affect accuracy?

Mr **Clark,** in reply: The stop and measuring gear is quite a heavy piece of machinery, and it only appears to move a fraction of an inch due to the momentum of the bar. When we say the selection is locked, what actually is locked up is the oil in the hydraulic system, so that, apart from a major leak, the gear cannot move more than the looseness of its parts will allow. If it does make a movement, then the control system comes into play to bring it back to the point already selected.

Mr **J. B. Orr** (The Park Gate Iron and Steel Company Ltd): Is Mr Clark fully satisfied with the end thrust arrangements on the roll neck bearings of the bloom mill, i.e. the fabric pads on either side of the 'out-board' collar on the roll? In connexion with these fabrics does he feel that the initial roll neck finish is more important than water quality (as opposed to water cleanliness)? From recent investigations it appears that while water quality varies tremendously from plant to plant no problem results with fabric bearings but where there is any slackness in control of initial neck finish, trouble inevitably results. In more than one case water is drawn from a canal and only gauze filters are used with no chemical treatment; under what circumstances is it worthwhile going to the expense of chemical treatment as opposed to simple cleaning by filtering?

Mr Clark quotes a screw-down speed of 150–300in/min for the primary mill. From our recent investigations this would appear to be a little slow for a modern blooming mill, particularly if any automatic programming is envisaged. Has this at any time been a limitation on the output of the primary mill and would he recommend a higher screw speed with automatic programming, so as to ensure that the screw operation is as fast as the rest of the manipulation?

On the question of the hot sawing of rolled products, would he comment on the water cooling of the saw blades? In what way and to what extent are the blades cooled at Lackenby? In a recent case in my experience water cooling proved to be a primary factor in blade life and when the efficiency of the water cooling fell off the blade life was reduced considerably. As a matter of interest, blade thicknesses in this example were taken down to $\frac{5}{64}$in (which is half the minimum stated by Mr Clark) and the life was first-class. Unfortunately, the effects, as filmed, were rather disturbing with regard to whip of the blade, hence this blade thickness with a 72in dia. blade could hardly be recommended from the safety point of view. Thinner blades do warrant further trials and there is no doubt that in my experience they result in much longer blade life.

Finally, with regard to soaking pit design we at Park Gate have been examining the question of pits with bottom dumping facilities as opposed to fixed bottoms and we have received a tremendous variety of opinions from various sources. It is true that a decision on such a matter is dependent on the qualities of steel to be heated, the fuel to be used, and the general heating practice of the particular plant; would Mr Clark like to comment on the operation of the pits at Lackenby and which method would he choose with oil-fired pits heating low-, medium-, and high-carbon steels to temperatures up to 1320°C? He states that at Lackenby they are using gas firing but he does not comment on the type of pit bottom. If they are fixed bottoms how often are they dug out and how long does it take? At other plants the frequency of digging out appears to vary from 6 weeks to 18 months in installations heating similar material with similar firing but where the variables would appear to be accuracy of control of pit pressures and other combustion conditions, and the maximum temperature employed.

Mr **Clark,** in reply: The end thrust arrangement on the blooming mill rolls is in our opinion a great advance over the method of taking the thrust on the end of the roll barrel. The thrust faces are completely enclosed, completely away from any mill scale, and the only disadvantage we have found is a certain difficulty in setting the end clearances. A modification to the method of setting up has now been adopted, and the thrust faces should last throughout the whole time the roll is in the mill.

With regard to water quality, we have always understood that the real essential is that the water shall be clean and reasonably cold. Whether hardness enters into this I do not know. Middlesbrough water is very soft indeed, but certainly we have found that reasonable cleanliness is necessary, and that a good neck finish is important. One or two of our bearing failures in other mills have been traced to poor roll necks. The screw speed of 300in/min has been found to be adequate, as this is a blooming mill and not a slabbing mill. If we were putting in a slabbing mill the screw speed would probably be 600in/min. When the hot saws were installed, it was intended that at each blade there would be 150 gal/min. Cascades of water are going over the blades the whole time. It may have been cut down slightly because of the tendency to cool the bar.

At the soaking pits, we have no bottom dumping facilities and have not experienced any difficulty in maintaining our bottoms. Generally, they last from 9 to 12 months, digging out and repairing taking about 2 or 3 days. On all our various works we have only two soaking pits which have dumping facilities, and the general opinion is that the very expensive pit floor, cellar, and transporting gear associated with bottom dumping is quite unnecessary. Our pit temperatures are generally about 1250°C, but with large ingots this temperature may be increased to say 1320°C. We have three oil-fired pits at our Redcar works but these, like all the others, have solid bottoms.

SESSION 2 Electrical features

At session 2 the second part of the paper, illustrating the electrical features, was presented by R. E. Kenderdine and then discussed.

Mr **H. S. Brown** (English Electric Co. Ltd): Mr Kenderdine has given a very good review of the main electrical features of one of the modern steelplants in the UK which is also one of the most modern of its type in the world. A review of this nature is of great value as a reference for those concerned with the installation of new plant. This value will be increased if in his reply to the discussion Mr Kenderdine can give some further information on the reasons behind the more interesting decisions taken, and the conclusions the authors have formed as a result of the operational experience that they have now gained. What are the decisions which have worked out particularly well? Which are the more important changes they would make if they were to repeat the undertaking?

The distribution system obviously has been very carefully considered to ensure three major requirements: supply continuity, maintenance while the plant is in operation, and provision for further growth. The system is very flexible but I note that on the central control board there is no mimic diagram. With a very flexible system a mimic diagram is of use to the operator to tell exactly what conditions obtain. Would Mr Kenderdine comment on this?

The level of voltages chosen for the various motor ratings is sensible: 11 kV, 2·75 kV, and 440 V ac were, I presume, chosen to line up with local standardization. With dc, however, new plants have been installed with 230 V and others with 440 V to reduce the cost of the distribution system. This was probably considered very carefully in this instance. Why was 230 V rating chosen?

Can he give any information on the loads which are actually being attained on the various levels of voltages in practice, and how these compare with the originally estimated loads? Are any figures available for the ratio of load to total connected hp at the various voltage levels?

Lackenby demonstrates how on a modern mill line the majority of those auxiliaries requiring good control have variable voltage drives. This raises the old question of ac *v.* dc for auxiliaries. Many mill auxiliaries can undoubtedly be ac driven, but dc is undoubtedly nicer. In the past a constant voltage dc supply has been available for other reasons and therefore dc drives were chosen in these marginal cases. Where, however, variable voltage drives are being used and when good control is required, the 'other reasons' disappear and we are left with a number of drives, most of which can be operated off either ac or dc. When the rather better dc control necessitates the introduction of a dc supply specifically for the purpose, the choice of dc is much more debatable. In fact many companies are now seriously considering the possibility of ac drives for marginal auxiliaries. I should like the authors' views on this problem, particularly since at another of their company's works ac auxiliaries have been used. I accept that in transferring to ac, certain additional auxiliary drives might have to be changed to variable voltage in order to achieve the required control. The motors which are being used for the constant voltage dc auxiliaries at Lackenby have a shunt to series ratio of 75/25. I feel that for the type of auxiliaries concerned a higher percentage of shunt/ampere-turns, say 80/20, would have been preferable. May I have Mr Kenderdine's views?

Variable voltage auxiliary drives with an individual generator for one or two motors provide a wide variety of possible arrangements for ensuring reliable operation. On p.354 of the paper the author explains the blooming mill arrangement at Lackenby, where there is a pair of MG sets with provision for running the drives at reduced power with one MG set shut down. In addition, however, a stand-by MG set has been installed with a stand-by bus system such that the standby generator can be connected in place of one of the normal generators. This additional generator may be a good investment, but the considerable extra cost and complication in the control gear and cabling is not justified. A simpler arrangement might have been to provide a pair of generators for each manipulator, acting in series. One MG set could then act as full standby for the other, admittedly with some drives running at half speed. Would Mr Kenderdine, in the light of subsequent operational experience, repeat his arrangement?

Although variable voltage drives have been used on the majority of auxiliaries requiring good control this does not apply to the roll positioning drives on the universal roughing and finishing mills where automatic programming control is provided. Undoubtedly, variable voltage control has advantages where high accuracy of positioning is required on an RPC system. I would be interested in information on the accuracy of positioning which is being obtained with the contactor control on these mills and also on the consistency of performance.

Two boards have been shown for the pre-setting of these controls. Has experience confirmed that two boards are essential or would one board have sufficed? Alternative manual control is also referred to. Again, in the operation of these mills, has rolling ever been done using manual control to replace one or more of the automatics?

One of the essential characteristics of the universal mill is speed matching between the edger and the main roll. Again, the accuracy required varies very greatly in operational practice as compared with what has been worked out in theory; to what extent has it been found necessary to have the speed matching accurately pre-set, and how far has it been possible to depend on the characteristic of the edger to compensate by transferring loads for errors in speed matching?

Was the reason for providing a twin drive for the edger the normal one of a better mechanical arrangement or was it to provide a flexible drive in case of the roll riding on the web?

A plant such as that at Lackenby will continue to evolve, to increase its efficiency, and improve its performance. Automation therefore becomes a factor. At Lackenby there are already automatic controls where these can be of best benefit to the works but continual development in techniques of control systems opens up further, wider fields where automatic control becomes a possible means of providing improvements in operation. At Lackenby, automatic controls could be used on the blooming mill to a greater or lesser degree. At the hot saws and the cooling banks, a computer might improve the gain in yield from the rolled products and improve the handling and the sorting for dispatch.

What are the author's most recent views on this aspect?

Mr **Kenderdine,** in reply: The changes we would like to make if we undertook the task again would be (*a*) the provision of an automatic mimic diagram in the control room for the main switchboards, (*b*) reversing rectifiers instead of Ilgner sets for the main drives, (*c*) the elimination as far as possible of the use of common trenches for cables and oil and water pipes, and (*d*) the provision of two lighting transformers, instead of one, at the blooming mill end of the plant. This would simplify the maintenance of the beam mill main lighting board.

The voltages 11 kV, 2·75 kV, and 440 V were chosen to line up with existing local standards. The 230 V dc was chosen in preference to 440 V as we think the 230 V winding for motors is more robust than the 440 V winding. Except for the crane supplies, our cable runs are not long, so that there are no very great voltage drop problems.

The average loads and the connected hp for the various voltages on the blooming, beam roughing, and beam finishing mills are:

	Average loads, MW	Connected hp
Total 11 kV load	14·3	
Power for 11 kV motors	7·68	18000
Power for 2·75 kV motors	1·6	8835
Power for 440 V motors	1·45	5242
Power for lighting	0·57	
Power for 230 V dc motors	3·0	16400

On the question of ac or dc for auxiliaries a good case can be established for the use of either type of motor. Although many

of the variable speed drives in this mill are Ward-Leonard controlled, there are many others requiring speed control, including a large number of cranes. The dc mill motor is very robust and reliable and gives a good variable speed control, and the 230 V dc is safer from an accident point of view than the 440 V ac. The motors on the cranes are dc series motors and the auxiliary drive motors are 75/25 shunt-to-series compound-wound motors.

The alternative arrangement of two generators on each of the blooming mill variable voltage MG sets for the manipulators would not necessarily have been much cheaper; it would mean four generators for the manipulators instead of three in our arrangement, and our standby generator can be used for the screwdowns, the approach table, the runout table, the front and back table rolls, and has proved itself to be very useful in practice. The changeover arrangements provided on the control board are quite simple to operate: there are bolted links to change the generator and motor main circuit combinations, and the control is changed by a simple key system.

On the beam roughing and finishing mills the automatic positioning control, working on constant voltage dc drives, achieves an accuracy of $\pm 2\%$ on incremental settings of 0·050in on the roughing mill and 0·010in on the finishing mill. Owing to difficulties in setting the brakes we have modified the control to bring the speed of approach down so that there is no overtravel at the stop position. The accuracy is affected by mechanical wear in the couplings of the selsyn drives which must be well maintained to retain the $\pm 2\%$ accuracy.

Two boards are required for pre-setting the controls as the rolling programme has to be changed in a few seconds between bars, the same rolls being used to roll different weights per foot of the same size bar.

During rolling, emergency manual operation of only one of the preset controls is the usual practice and a second operator is used. The mill is stopped as soon as convenient to correct the fault as the manual operation does not produce such a regular product as the automatic control.

The speed matching between the edger and the main roll is critical and the characteristic of the edger can only compensate for the impact loads and not for the errors in matching the roll speeds. The setting of the speed matching was adjusted during the trial rollings, and is closely watched during the first bar of every rolling and adjusted to give the correct operation.

The reason for the twin edger drive was to obtain a better mechanical arrangement and to enable unmatched edger rolls to be used.

Our present thoughts on further automation on the blooming mill are that complete automation is not practicable, as yet, owing to mechanical difficulties with the turnover gear and the positioning of the manipulators when dealing with more than one type of product with the same rolls.

At the hot saws a computer has been considered to deal with the best cutting of the rolled bars but the improvement in the yield over the present saw operation would increase the yield by only 0·2%. An improvement in the sorting and handling of the finished products, if it were possible, would be more advantageous than the increased yield.

Mr **P. Aspin** (BISRA): If my eyes do not deceive me, the edger motors appear to be open at the commutator end. Is this so, and, if so, why have they been left open when all other plant appears to be very well closed and supplied with filtered air?

There are twin drives both on the blooming mill and on the universal stands; the top motor is the back one, so that its driving shaft passes over the lower motor. It has been argued that of possible arrangements this is the worst, because the driving shaft limits accessibility to the lower motor. Would Mr Kenderdine care to comment on that point?

Turning to the slider boards on the universal mill, in the paper it is stated that the switching from pass to pass is done by relays. I have small experience of the use of relays, but I find them to be generally most unreliable. I should have thought that in mill conditions they were a considerable source of trouble. Am I right in this? Has Mr Kenderdine thought of using any other sort of static switching devices in their place in the future? I noticed also that in the picture of the slider boards, in each station there appear to be two boards, each with the same pattern of connexions; I therefore assume that there is one board for the bottom roll and one board for the top roll, and also one board for the left flange working roll and one for the right-hand one. Would not one board for each pair have sufficed? If they were combined in this way it would reduce the time for setting up by at least half.

My final point concerns the rectifiers. From the description given, I assume that they are mercury arc. I have read recently that silicon rectifiers have rather overtaken mercury arc at this time, both in cost and on size. Were these considered at the time? Has the situation changed since they were installed? Would Mr Kenderdine again use mercury-arc rectifiers, or would he now select silicon?

Mr **Kenderdine,** in reply: The edger motors are open at the commutator as are most of the generators on the Ilgner sets. Some generators which were originally supplied closed have since been opened at the commutators. This provides better access to the brush gear for brush maintenance and makes it easier for the air flow to take the brush dust out of the machine.

The twin drive motors are bottom motor forward and at the time of ordering we were not offered the alternative of top motor forward.

Our preference is for the top motor forward provided suitable arrangements can be made for removing the jack shaft in an emergency. The added accessibility of the top motor and the elimination of the 'A' frame structure in the top motor forward arrangement are sufficient reasons for adopting it.

In the automatic preset equipment on the roughing and finishing mills we have had no trouble at all from the relays. These relays are housed in dust-tight boxes and, along with all the control equipment, are situated in the motor houses in a filtered air atmosphere.

The similarity of the pattern on the slider boards is due to the very slight alterations in setting required to give a different weight of bar from the same rolls. The first board in Fig.10 of the paper is for the vertical roll screws, the top sliders are the coarse adjustment, and the bottom sliders the vernier adjustment. They are set for a nine-pass schedule but the boards can accommodate 19 passes.

If static switching can be used to replace moving relays and prove as reliable as this equipment then we will consider it for future equipments.

The rectifiers used for the constant voltage dc are steel-tank mercury-arc rectifiers and were chosen for their reliability. We still lack sufficient experience in the use of silicon rectifiers to use them in preference to the mercury-arc type for this duty.

The **Chairman:** On the question of the slider boards for the automatic preset control, Mr Brown raised a point which perhaps Mr Kenderdine might answer more fully: how would one operate if one were to work entirely manually? How would operational performance compare with that which results from the slider boards?

Mr **Kenderdine,** in reply: It is possible to work the mill without the preset control. It would take longer on the passage of the material through the mill, but it has been done when there has been a fault in the preset control. We do not stop the mill if there is a fault in one of the controls, but carry on with the hand control until either there is a roll change or a meal break, when any adjustments necessary can be made. If there is more than one automatic control faulty the mill is stopped.

The **Chairman:** The manual operation is distinctly slower?

Mr **Kenderdine:** Yes.

Mr **J. McLauchlan** (Appleby-Frodingham Steel Company):

What increase is there in the number of operators, or does one operator attempt to get three roll adjustments? This question is supplementary to one asked by another member in regard to whether or not the mill continued in operation when the automatic screw-down went out of action.

Mr **Kenderdine,** in reply: If one automatic operation failed and required manual operation, one extra operator would be required. If more than one required manual operation the mill would stop as soon as the bar was through the mill.

Mr **H. Demaine** (The Park Gate Iron and Steel Co. Ltd): At the time this rolling mill was being designed there was only limited experience of the use of rectifiers for heavy reversing mills. If this job were being considered today, would Mr Kenderdine think seriously of using rectifiers in place of the Ilgner set?

Reference is made to the liberal use of reactors to keep the fault level down on some of the existing switchgear. Has this additional reactance given rise to any operating problems on the network?

What has been the operating experience with the oil-cleaned air filters? How was the decision to use oil-cleaned air filters arrived at and was any serious consideration given to the use of electrostatic precipitators for cleaning the air?

There has for many years been a predominance of ac drives used in steelworks on the continent, particularly in Germany and France, and there is today an ever-increasing use of ac drives in American plants. In considering the drive requirements for the new steelmaking plant and rolling mills that my company is now constructing, a decision was taken to use ac wherever possible including for overhead cranes. Perhaps Mr Kenderdine would be prepared to comment on this subject.

On the subject of overhead cranes, are inner handrails employed on the gantries to prevent the maintenance people from falling over either side? During a visit which I recently paid to the Chief Factory Inspector to discuss our proposals for new overhead electric travelling cranes, a suggestion was made that serious consideration should be given to the use of a battery connected in parallel with the operating supply of the magnets used on magnet cranes; the connexions should be so arranged that the battery would act as an automatic standby in the event of a power failure. I would be interested to learn if any member present has had any experience of such an arrangement or would like to comment on the suggestion.

Is the lighting intensity of 8 lm/ft^2 general throughout or are there certain areas where the intensity is higher? 110 V is quoted as being the operating voltage for portable tools. Was any thought given to the use of 50 V for operating these and similar types of portable equipment?

What safety precautions are taken and what facilities are available for the use of 440 V three-phase portable equipment such as welding sets, winches, etc? Are any special precautions taken with regard to the kind of cable with which this equipment is fitted and are any special earthing precautions applied?

Can Mr Kenderdine state the value of the maximum demand for his plant; there appear to be three or four connexions to the Electricity Board's supply and I should like to know if these connexions are summated and, if so, if they summate for both leading and lagging loads?

My final question relates to the installation of the plant. What special precautions were taken to ensure electrical safety during the erection? I have in mind here temporary supplies for erection purposes and power supplies during the commissioning stages.

Mr **J. Higson** (Dorman Long (Steel) Ltd), in reply: A large site such as Lackenby requires the distribution to strategic points on the site, at which transformers and switchgear could be installed to feed construction plants in the area.

It was decided to try and keep a cable reservation clear of anticipated excavation and tracks for vehicles. The 11 kV armoured cable was laid on the surface with a warning wire supported on posts above the cable, and with warning signs on the wire. Contractors' drivers at first ignored the warning signs and drove over the cables. It was decided therefore to make definite access points over the cables, which were buried at these points. Then strict supervision was given to keep the vehicles to the correct access points.

All the 440 V temporary distribution was done in armoured cables, some buried and some on the surface depending on local conditions.

Temporary lighting was carried out at 110 V with rubber cables, and the use of 110 V portable tools using centre tapped transformers was a condition written into contractors' contracts.

Mr **Kenderdine,** in reply: On the question of an Ilgner set or reversing rectifiers for heavy reversing mills we would now use rectifiers providing the peak reactive loads were acceptable to the supply authority.

The reactors in our supply network have made the operation easier as we can work with more section switches closed.

Oil-cleaned air filters have proved satisfactory and were chosen on economic grounds. Small electrostatic precipitators were used for the recirculated air systems on the Ilgner sets.

We consider the modern dc mill motor provides the most robust variable speed drive and, where there are many drives required, it is an economic proposition.

We do not fit inner handrails on the crane girders; we consider they could be more of a hazard than a help to maintenance men. Nor have we considered batteries on magnet cranes.

The lighting intensity of 8 lm/ft^2 is the general intensity in the mill and is supplemented locally where necessary.

The voltage of 110 ac from a centre tapped transformer to give 55 V to earth was chosen to give a reasonable voltage for portable tools and a safe voltage for portable lamps so that they could all operate from the same sockets. The 110 V is required to keep down the size and weight of the tools.

Where portable 440 V equipment is used the flexible cable carries the earth connexion and the cable is limited to 6 ft long, no earth leakage trips are fitted, but the 440 V flexible leads are inspected and checked weekly.

The load figures for the plant are given in my reply to Mr Brown.

The connexions to the Electricity Board's supply are all summated to give kWh and maximum demand.

The **Chairman:** On p.360 of the paper, under the heading 'Lighting', there are the words: '... tungsten improves the resultant colour and provides an essential safeguard against the loss of light on a momentary dip in the voltage'. I should have thought that what one might call the thermal inertia of a tungsten lamp was small and that the lumens would be proportional to the square of the voltages, and therefore that the tungsten lamps would be susceptible to a voltage dip.

Mr **Kenderdine,** in reply: The point about the tungsten lamps providing a safeguard is that if there is a dip in voltage all the mercury lights go out and do not come on for 10 – 15 min, whereas the tungsten lamps light up straight away. One is not relying on the energy left in a tungsten lamp at all. It is a question of how soon they come on again. A mercury-type lamp has to cool before it will restrike, and with the bigger type of lamps this takes anything from 10 to 15 min.

The **Chairman:** Then there is some substance in my suggestion. The tungsten lamp would be susceptible, but it would come on very quickly.

Mr **R. Paterson** (Round Oak Steel Works Ltd): Had space been available, Mr Kenderdine could have told us much more on some elementary but essential points on which I will comment.

I should be glad if Mr Kenderdine would comment on the connected load, the estimated load, and the actual load in practice for each section of the plant. It would be useful to know the reactance values on the several parts of the system and have some indication of the normal paralleling of the several feeders.

Regarding pumps, the paper states that pumps for essential services are connected in pairs at least. Has any provision been made to use diesel pumps or provide water storage to take care of long periods of electric power failures?

It is presumed that the dc system is a so-called insulated system. Has any form of earth leakage protection been provided to afford tripping in the event of an earth fault on one line, and if so, what form does it take?

On the question of the several reactance and impedance values, what is the maximum fault level on the 440 V systems? What is the load factor on the several systems, the summated load factor, and the summated power factor at the incidence of maximum demand? Has anything been done on maximum demand limitation? Will Mr Kenderdine give the average cost per kWh? Has any provision been made to prevent dust from the insides of cooling-air ducts entering the motors?

Figure 3 shows a telephone in a control pulpit. Is there also a broadcast loudspeaker system covering the mill and relevant surroundings?

On EOT cranes, I think the gap should be fenced all round. We have made this a standard on new cranes.

Mr Kenderdine mentioned that 1 500 W tungsten lamps are used on lighting towers. Why not 1 000 W mercury in floodlight fittings, which are available?

Mr Demaine asked about safety in the use of magnets on cranes. We have not provided batteries for magnets on cranes but recently the factory inspectors have expressed their interest, so we have devised a circuit using dc blocking rectifiers in which the battery would normally float on the line and in the event of power supply failure, the battery would automatically take over without an instant of failure. We consider that a 10 min rating would suffice to lower or drop the load safely. There would be special justification where loads are carried above expensive machinery.

New installations are always a problem. The correct approach is to install the permanent distribution system as soon as possible, thereby reducing temporary work to a minimum. Some temporary work will be necessary and this also must be planned with great care to limit the cost and prevent accidents. The site conditions will dictate the class of cable insulation, but the minimum for lt work must surely be 600 V grade rubber insulated, tough rubber sheathed and with two earth continuity cores.

The voltage to use at the point of utilization must be judged by the electrical engineer, but the voltage on portable tools and portable lighting should not exceed 110 V with 55 V to earth.

Mr **Kenderdine,** in reply: The load figures and the connected loads are given in my reply to Mr Brown. The six incoming feeders from the Grangetown substation run in parallel, all the sections on the beam mill 11 kV board being run closed; this results in a fault level of 350 MVA. The blooming mill 2 750 V board is run split and the resultant fault level is 65 MVA. The 440 V, 25 MVA boards are run split at each section and the resultant fault level is 16 MVA. If it were split in two with two transformers per section it would be 30 MVA.

The only diesel pump is a standby with automatic starting, for the reheat furnace cooling water; there is no need to keep the other pumps running if there is a total power failure.

On the insulated dc system there is earth leakage indication but no earth leakage trip. If two earth faults develop, one +ve and one −ve, the circuit breakers open on overcurrent. When an earth fault is indicated it is traced at the first opportunity in the rolling programme and arrangements made for its clearance.

	Load factor, %	Summated load factor	Estimated power factor	Cost/kWh
Lackenby	60	72·5	0·75–0·8	0·9104*d*. 1959–60
Redcar	70			0·9333*d*. 1960–61
Cleveland	82			

There is no automatic control of maximum demand but it is continually watched at our integrated supply control room at Cleveland where facilities are provided for tripping off loads in any of the three works.

The large cooling air ducts and chambers made of concrete have all been treated with several coats of silicate of soda, the small ducts are via sheet metal pipes laid in the concrete foundations.

Communications are provided by an automatic telephone system entirely separated from the GPO system, several Tannoy loudspeaker systems working in local rings covering sections of the plant, and an overall public address system.

To make the best use of the lighting towers the fittings have to be capable of throwing a concentrated beam of up to 600 ft and the mercury floodlight is of no use for this. We do, however, use mercury floodlights mounted on the parapets round the tops of the buildings to floodlight the surrounding areas.

The **Chairman:** I am sure it is not my prerogative to be dogmatic but I think it would be going beyond all reasonable limits to put any batteries on cranes for the purpose mentioned. Many of our heavy works cranes have a very low payload and it is surely a desirable objective to increase the ratio of live to dead load. One means of promoting this would be the increased use of higher tensile steels at prices little in excess of those of mild steel.

Another factor which assists in this direction is the use of reeling drums or cable looping for cross-travel power supply; this, as the paper indicates, can result in a considerable reduction of weight. In The United Steel Companies we have reeling drums on 5-, 10-, and 12-ton cranes, and they all work very satisfactorily. There is an upper limit somewhere, in relation to cable size and drum diameter, and one wonders where this upper limit comes.

Mr **Higson:** As a matter of general interest I should like to mention the work we have done on insulated cross-travel conductors and cranes.

We have installed several different schemes on dc and ac systems using the coiling drum, looped cable on travelling runners, and single loop system. Each type has proved to be quite reliable and trouble free.

We have also fitted up a 10-ton stripper crane with insulated conductors both on long travel (180 ft) and cross travel; the long travel is a four core 0·25in^2 flexible cable which is coiled on itself on a crane-mounted drum and fed from the mid-point of the track.

Cross travel is by means of a single cable loop suspended from a post in the middle of the cross travel run. This installation has been in use for several years and is very reliable.

Regarding Mr Paterson's query on MD we have an incoming supply from the grid of 36 MW at 11 kV and roughly the same amount of generation. Weather forecasts are received every morning at 5 am. The local authority gives us the total load of the area for the previous day, and their assessment of their load for three times during that day (the supply authority have been very co-operative on this point). With all this information we must anticipate the trends of load during the day to ensure that we have maximum generation on the bars at the anticipated time of maximum demand on the system. We cannot at times of full order books shed load to reduce the maximum demand. All we can do is increase generation to the maximum at the time of anticipated maximum demand.

Mr **H. R. Fernbach** (Loewy Engineering Co. Ltd): Mr Kenderdine has explained why mercury-arc converters cannot be used for this particular plant. It appears that synchronous-motor-driven generator sets would have been the next best solution, particularly for the finishing mill, where the peaks are not as high as they are for the roughing mill but are of rather longer duration. For such duty the synchronous-motor drive appears to be quite satisfactory with an obvious advantage of higher efficiency and better power factor quite apart from such other considerations as reduced capital cost and maintenance.

It appears that the air ducts are also used as service tunnels for main cables. Whereas there can be no doubt as to the

efficiency of this procedure in keeping the cables cool and running them at the maximum rating, it seems a dangerous practice which might lead to a disastrous fire, in the event of a cable fault, which might spread rapidly over a wide area.

The reasons why twin drives were not adopted for the horizontal main rows on the universal mills are somewhat obscure. It suggests that the two main rolls must be rigidly tied in speed. What difference in roll diameter is permitted? Have twin drives been tried on this type of mill?

Mr **Kenderdine,** in reply: On the question of synchronous drives for the finishing mill and the roughing mill, Ilgner sets with the induction motors were installed to keep our peaks down, and also to keep uniform as many drives as possible. The breakdown mill, the roughing mill, and the finishing mill all have similar drives and similar Ilgner sets. Although the peaks on the finishing mill are less than on the roughing and the breakdown mill, it pays us to keep all the drives alike to minimize the spares required.

We have had no trouble from fire in the totally enclosed tunnels where we have run air and cables together. It is possible that if a fire were started the air would accentuate it, but fire is very unlikely inside enclosed air ducts. However, we have had trouble with fire in the ducts about the mill itself where they are laid with covers in the mill floor. There always seems to be a way through a hole in a cover, for hot scale to infiltrate into the cable ducts, and the ducts accumulate a large quantity of waste and oil of one sort and another.

The reason for our not using twin drive on the roughing and finishing mill was that the mill operators wanted to be sure there was no variation in speed of the two rolls such as might cause the beams to turn up or turn down, and as this type of mill was new in the UK it was thought to be more prudent to use the conventional type of drive. Even today there are no structural mills using a twin drive.

The **Chairman:** Mr G. H. Billings (Shelton Iron and Steel Co. Ltd) has had to leave, but has handed in a note asking two questions on mechanical aspects.

First, he would like to have some comments on the advantages of rolling universal beams by the straight-flange method as against the splay method. He apparently has in mind the South Durham works where normal joist rolling followed by straightening out the flanges, taking out the taper with a universal pass at the end, is employed. I think the answer is that the range at South Durham is very different from that at Lackenby, both in flange width and thickness.

The second question is: why are beams rolled with 2° 52′ taper? I find that an interesting question. Why, for instance, is there 2° 52′ taper on beams and about a quarter of a degree on columns?

Mr **Clark,** in reply: There are actually two methods of rolling beams with splayed flanges. One is to use a universal mill with double conical vertical rolls, so that the flanges are kept splayed at every pass with a final straightening up by means of cylindrical rolls in the last pass. The advantages claimed for this method are better elongation of the flanges and improved roll life. The other method, practised in several mills in Germany and also at South Durham, is to roll the beam in three standard two-high stands with splayed flanges to achieve spread. The fourth stand is equipped with two vertical and two horizontal rolls and does no more than straighten the flanges. This method of rolling has proved quite successful with the continental range of beams, but I have never heard of it being used with the American range.

We considered the double conical method in the early stages, but decided that our purpose would be served by cylindrical vertical rolls but with bottom screwing to facilitate obtaining the correct pass level and to ensure even wear on the vertical roll faces. It may be pointed out that the splayed flange method in a universal mill demands a final flange straightening stand with no work to do except the removal of the splay.

One reason for the taper of 2° 52′ on beams is that the horizontal rolls, some of which are very heavy, up to 15 tons, can be brought back to size with little removal of metal from the periphery and therefore have a much longer life. Our structural engineers tell us that there is no disadvantage in this small amount of flange taper in a beam. With the shorter beam flanges the taper also makes for easier entry into the main rolls.

With the columns the position is slightly different. Generally, the important quantity in a column is its radius of gyration, and in order to make this as equal as possible on the two principal axes, more metal should be placed at the toes of the flanges and less at the roots. This can better be done, main dimensions being equal, with parallel rather than with taper flanges. Because of the longer flanges, in using column sections the problem of entry into the rolls, associated with beams, does not arise.

This is a possible explanation of the different tapers on beams and columns. In fact we adopted the range already standardized in the USA.

Earlier in the discussion there was a reference to the pre-set screwdown panels and the reason for wanting two panels when apparently one would do. I should like to enlarge on that matter. The two panels are not required for different sizes of beams, but for different weights of the same size. One can, for instance, be rolling a $12 \times 12 \times 99$ lb beam and at a certain point all the bars of that weight are rolled and a 66 lb beam is called for. The time available to change the schedule is only a matter of a few seconds. An announcement is made on the public address system that this is the last bar of the old weight and that the next bloom coming up is for the new weight.

Mr **A. R. Parish** (W. S. Atkins and Partners): I notice that a scheme of blended mercury and tungsten lighting is being used and I should like to know why colour-corrected fluorescent mercury lighting was not used, aided by a small amount of tungsten lighting for safety reasons.

The paper quotes a figure of 8 lm/ft². Is this a maintained figure or when the fittings are clean? How often is it necessary to clean these fittings?

Mention is made of walkways installed for access to lighting fittings and I wonder if these can be justified. With fittings at 55 ft spacing there is 55 ft of walkway associated with each fitting and since walkway costs about £4 per ft there is a capital cost of £220 per walkway. If there is a 15% charge on capital something like £30 a year is being paid for access to each lighting fitting. In the case of mills where the cranes are not primarily production cranes but maintenance cranes, it has been argued that this cost cannot be justified, and that particularly where mercury vapour lamps are used, with a 5000-h life, the only economic method is to change and clean lamps from cranes. I know that this does not appeal to the electrical engineer generally, but I wonder whether it is a point that has been considered and if there is any good reason for rejecting it.

Mr **Kenderdine,** in reply: If colour-corrected mercury lamps prove to be more economic than the ordinary mercury lamps, we will consider them, but at the start of the beam mill project they were not available. The colour that we get from the present arrangement is quite good and is all that is required in a mill.

The figure of 8 lm/ft² is for the clean fittings. When put in new, it would probably be considerably more than 8 lm/ft². If they are left for a long time without cleaning, or changing of lamps, the figure will drop well below 8 lm/ft². With the provision of the walkways it is possible to arrange for a planned maintenance of the lamps to keep them clean. We find that where we have to rely on maintenance cranes for cleaning the lamps, the cranes are never available when needed because they are always in use maintaining the rest of the mill. In fact, it is very difficult to find time for the maintenance of the crane itself, let alone for changing lamps. I think that the provision of walkways is something that is really essential to proper

maintenance of lamps in this type of building. The cost is a very small proportion of the total building cost, and the walkways provide a way of cleaning fittings which is much safer than climbing on the overhead cranes.

Mr **D. J. Ray** (Richard Thomas and Baldwins Ltd): My questions apply to the automatic control of the mill. First, I believe the resetting potentiometers and other feedback devices are driven through selsyn links. Have any instability problems been encountered as a result of this arrangement, and has any backlash problem been discovered on the mechanical drive arrangement at the transmitter selsyn end? Also, from a mechanical or electrical breakdown point of view, has it been found necessary to install standby transmitter selsyns?

My second question refers to the slide board method of setting up the programme. Were the alternative methods of punched card or tape considered? These latter arrangements could well reduce the setting up time for a particular programme and offer other advantages.

Thirdly, as often happens, the operator for some reason or other is obliged to revert to manual control in the middle of a programme. When this happens does he go back to automatic control when the difficulty has been overcome or does he complete that particular programme on manual control?

Lastly, has automatic reversal of the blooming mill been considered?

Mr **Kenderdine,** in reply: We have had no instability problems on the preset automatic controls but we have found that backlash on the mechanical drive of the selsyns can seriously affect the accuracy of the control. It has not been found necessary to install standby transmitter selsyns but those for the roughing-edger side guides had to be increased in size from 7½ to 15 hp.

The slider boards provide a much more flexible arrangement for setting up the programme than the punched card system would. Another important feature is the ease with which corrections can be made to the programme during rolling to eliminate the effects of roll wear. If a test-piece shows that the bars are approaching the limit of a tolerance the operator in the mill pulpit is informed through the loudspeaker system and the appropriate correction is made on the slider board.

If the operator has had to use manual control of a motion he can revert to his automatic sequence to complete the programme.

Automatic reversal of the blooming mill has not been considered.

Mr **J. B. Orr** (The Park Gate Iron and Steel Co. Ltd): I have a brief observation to make on what is a production rather than an electrical point. Mr Kenderdine mentioned that at Lackenby they are fully satisfied with the method of soaking-pit lid control from the crane cab, with the crane directly over the pit being drawn, but I feel that perhaps a word of caution is worthwhile on its application to primary mills in general.

In many cases the drawing crane may have a considerable distance of travel due either to the non-installation of an ingot bogie or to the temporary break-down of the bogie, and in such a case, it is of considerable advantage if the soaking pit lid can be fully open by the time the drawing crane has returned to the soaking pit for the next ingot. A method of operating the lid from another position of the crane or by other means would then be necessary. For example, after the crane has placed an ingot on the mill run-in table the lid actuation may be begun, so the crane may then proceed straight to the pit, the lid of which will be opened during the crane travel. This is particularly useful at times when the practice of light cogging and reheating is employed.

The **Chairman:** The authors of the paper do not say anything about noise, but we are reaching the stage when noise will have to be given more attention in our works. One of my colleagues recently said that there was a horrible noise in the saws. I replied that there is a horrible noise at any saw; still, further thinking on this aspect will be needed.

On p.349 of the paper, where cooling and the cooling banks are referred to, there is an interesting sentence: 'The cooling bank supports are chevron-jointed cast iron segments . . .'. While this is normal practice, in this instance there must be some very high intensities of load, and I should think that there is a considerable amount of squealing.

Mr **A. R. Cowell** (McLellan and Partners): From the paragraph illustrating the hot saws (p.360), one sees that each hot saw is driven by a wound-rotor type induction motor. One's immediate reaction is: why use a slip-ring motor, rather than a simpler, cheaper, direct-on-line started, squirrel-cage motor? On reading further, one notes that the automatic contactor-type rotor starter retains a ballast resistance in the rotor circuit to give 10% slip on full load. I wonder if there is any significance in the 10% slip. Was it specified by the saw-maker? Was that the reason for using a slip-ring motor, or was it the other way round? Was a slip-ring motor chosen because the supply at that point is not stiff enough to deal with direct-on-line starting, and was advantage then taken of the drooping characteristic? It has been stated that the peripheral speed of the saw is 21 000 ft/min, which is rather higher than usual. I wonder whether, when the slip ring motor had been adopted, 10% slip was introduced later to reduce the saw speed for mechanical reasons. A similar slip could have been built into a squirrel-cage motor.

Mr **Kenderdine,** in reply: The slip was put in right at the beginning at the saw manufacturer's request. It was always designed for 10% slip on full load and a wound rotor was specified so that this slip could be varied if necessary. There is no question about it being a wound rotor because it cannot be switched, it could be switched directly on if we wished. It has proved useful having the wound rotor for we have been able to add dc injection braking. It has been found that there are so many saw changes that to wait 6 min for the saw to run down is too long, and we have been able to reduce this rundown time of 6 min to 20 s.

Mr **Clark,** in reply: The saw speed of 21 000 ft/min has been mentioned. We are having a certain amount of trouble with our saw blades, and it has been suggested that one thing we ought to try is reduction of the speed to not more than about 18 000 ft/min. If anybody has any experience of running saws at different speeds, we should very much like to hear of it.

WRITTEN CONTRIBUTION

Mr **K. K. Schwarz** (Laurence Scott and Electromotors Ltd), wrote: As the question of ac roller table motors has been raised in the discussion of Mr Kenderdine's paper, it may be opportune to mention that at present 'floating' type variable lf motors are available with ratings about ten times higher than those which were available when the Lackenby beam mill was originally planned. Furthermore, control equipment is now available for such drives, which enables its performance to be matched with that of dc roller table motors supplied by Ward-Leonard. This entails the use of rapid response rpc control systems for the induction regulators controlling the speed of the frequency converter driving motors, thus enabling the roller-table motor speeds either to be selected by the operator or to follow the mill or other table speeds.

Discussion on development of electric drives and control for high-speed cold-reduction mills

SESSION 3

At session 3 the paper **'Development of electric drives and control for high-speed cold-reduction mills'**, by *H. D. Morgan* (The Steel Company of Wales Ltd) and *P. E. Peck* (Associated Electrical Industries Ltd) (this issue, pp.361–374) was presented and discussed.

Mr **J. Nelsey** (The Steel Company of Wales Ltd): Many papers have been written dealing with rolling theory but because of the difficulty of carrying out practical tests, relatively little foundation for theory is available. This is in direct contradistinction to the progress of natural science in the hands of men like Faraday, Rutherford, and Cockcroft. So much purely theoretical work has been written that those involved in the practical operation of steel mills may be sceptical of its value; but this does not mean that theoretical work can be ignored. The authors of this paper have taken relevant theoretical ideas and have expressed them simply and in terms which can be understood by those like myself who are not endowed with mathematical genius. My remarks refer to specific points in the paper.

It has been said that rapid acceleration will reduce the amount of off-gauge material produced. It will indeed reduce the amount of *heavy* gauge material produced, but, particularly on five-stand mills, this is not the main problem. A five-stand tandem mill rolling at thread speed will, in general, be producing an outgoing strip which is heavier than the required gauge. When the mill accelerates to full speed say in 10 s, due to the speed effect the tendency will be for the gauge to become lighter than required. This 'overshoot' will be greater at higher rates of acceleration and more light gauge will be rolled before the mill settles down than would be the case if the mill acceleration were more gradual. The point I am making is that rapid acceleration will reduce the small footage of heavy gauge material which is made at low mill speeds, and increase the greater footage of light gauge material which is made at high speeds *before the mill settles down to steady speed.*

On page 364 there is a reference to inertia compensation which, it is said, is necessary on an aluminium mill because the roll force is low at the last stand. I suggest that it is still important on a high-speed cold mill when rolling light gauge material.

On page 365 there is a reference to 50-cycle regulators having given way recently to 400-cycle magnetic amplifiers. Would the authors agree that this is not the last word? Since stable 400-cycle supplies are costly, and since 50-cycle magnetic amplifiers having a half-cycle response time are now available, it would seem reasonable to use these in preference to 400-cycle equipment.

On page 365 there is mention of twin drives. I have heard separation of the drive advocated but have never yet found anybody who could give a good reason for doing it. I can think of many reasons for not doing so, one being the difficulty with regard to balancing the contribution made by each motor. The operating engineer will appreciate another disadvantage: the moment there is any trouble on the mill, the electrical engineer will be blamed for it. I make this point quite seriously, it is in fact one more place to look for trouble if the mill is not functioning well. It is claimed that this type of separation of drives enables rolls of different diameter to be used. I doubt whether those who have this feature take advantage of this possibility.

There is mention on page 365 of the difficulty of attaining good commutation on modern motors. In my experience the commutation of tandem mill motors is never a problem. The motors are only carrying current when they are turning; the trouble arises in the generator commutators which are rotating at high speed very often for long periods with no current.

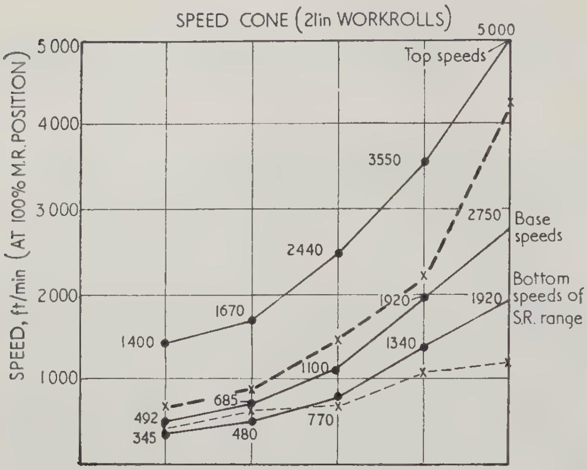
There is a reference to the speed cone of a typical four-stand mill on page 365. It reads: 'One of the primary requirements for the drive for a tandem cold mill is that it should be adjustable over a wide range of speeds to accommodate a large variety of rolling schedules'. To that I would add that it is necessary, however, to study existing mills to avoid specifying a speed cone which caters for conditions which are in fact never encountered. Figure *A* illustrates the point for a five-stand mill. The outer lines are the limits of performance. The middle line gives base speeds and shows what the motors will do on full field. One can reduce motor speeds individually by voltage regulation, which gives the bottom curve. If the rolling schedules shown in Table I in the paper are applied, together with some which I have added representing a wide divergence from normal tinplate production on this speed cone, it is found that the maximum motor speeds encountered in practice do not differ significantly from the base speeds for stands 1 to 4. In the case of stand 5, however, considerable field weakening is used on most schedules to achieve rolling speeds in excess of 4 000 ft/min. On some mills the droop will be greater at weak fields and although it is reckoned that, on the mill in question, the IR compensation is the same at weak field and full field, the transient response at weak field is not as good. On future similar mills, therefore, the base speed line for stand 5 should go much higher.

On page 367 there is reference to a load-compensation rheostat on the operator's panel. Should the mill operators make that adjustment?

Also on page 367 there is reference to the question of speed droop, during threading on the mill, and running. It reads: 'In order to give the ratio of these proportions the optimum value, a careful blending of motor compounding and load compensation is required . . .'. I should like to know how that optimum value is decided.

Further on page 368 there is mention of twin drives again. At this stage I should like to ask the following question. When a roll change has been carried out, and assuming roll diameters are different, how are the respective motor characteristics set up after the roll change so that the motors will bear the right proportion of the burden?

On page 369, reference is made to the use of gauge-meters for automatic gauge control. It is my opinion that the application is unsatisfactory. A serious difficulty lies in what is termed 'back-up roll eccentricity'. Since the roll is used and ground on taper-neck bearings, one cannot find eccentricity as such; it is a misnomer. What is in fact found is a bending in service of the back-up roll, which may in serious cases be of the order 0·0025in and under the best conditions is usually about 0·0005in. On five-stand tandem mills one endeavours to control gauge to better than 0·0001in! If a gauge-meter is used, an averaging circuit is necessary to 'iron out' the apparent gauge fluctuations over one complete back-up roll revolution. The periphery of such a back-up roll is 14 ft and a corresponding delay is therefore introduced. This delay is worse than the transport time needed for control by a conventional X-ray gauge, which must in any case be purchased as a monitor to maintain accuracy on the gauge-meter.



Stand	1	2	3	4	5	Reel
hp	1750	3500	3500	4000	5500	900
rev/min	90/255	125/304	200/445	350/645	500/910	233/955

All stand motors are direct drive on bottom work roll.
The thick dotted line represents the speed maxima normally encountered in practice. The narrow dotted line represents the speed minima which have been used on a few rolling schedules.

A *Point for a five-stand mill*

STAND 1	STAND 2	STAND 3	STAND 4	STAND 5
111	132	85	55	71
185	290	160	64	60

Mill inertias are in each case about 38 lb/ft$^2\times 10^3$

C *Five-stand mill motor inertias, lb/ft$^2\times 10^3$*

On page 370 there is mention of high-speed circuit breakers. These are a great advance on past practice when these were fixed permanently on concrete bases. Although the incidence of trouble has not been high, when it has occurred it has been serious and entailed long delays.

The question of protective devices is discussed on page 370. In this connexion, I should like to draw the attention of the manufacturers to the need for accurate suiciding. It is common practice to provide circuits for this purpose, but we have found in practice that it requires a very low voltage to turn a mill which is nominally at standstill. If the mill has just been turned, say by inching, only a fraction of one volt is required to maintain the rotation. This can result in danger to operators, and a rocking mill causes extra gauge reduction at one point in the strip which may break as soon as rolling tension is applied. The usual suiciding provided is not adequate and requires adjustment from week to week. A more refined arrangement is needed which will guarantee zero residual volts whether the circuits are hot or cold and regardless of the previous speed manipulation carried out.

On page 370 there is the statement that closed air circuit ventilation can be used with open commutators where noise is an objection. I am puzzled by this because most of the noise is set up by brush gear and commutators.

On page 371 there is the statement: 'There are substantial fan losses and space has to be found for heat exchangers . . .'. I think the authors will agree that this comment is equally true of the previous subheading.

There is reference on page 371 to throw-away filters, using a differential pressure gauge to show when the filter has become dirty. I should say that those will fail because people diligent enough to watch them and to take action at the appropriate time are few. If an interlock is put on so that air failure would trip off the line, then the motor may be safe; but it is cheaper to duct in fresh air.

On page 372 there is mention of air scrubbers. We have used them since 1951 and I agree that there are no corrosion problems, and they are completely satisfactory.

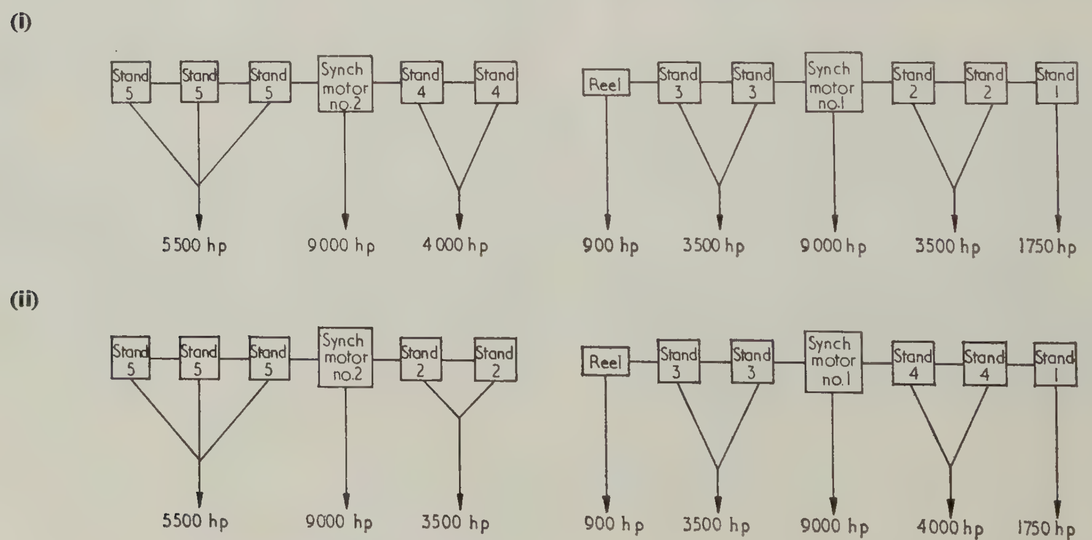
Also there is reference to the circuit orientation of the two MG sets with respect to the four mill drive motors. On our five-stand mill, the arrangement was as shown in Fig.*B*(i).

We found that the second MG set was carrying 50% more load than the first. To obtain maximum outputs it was necessary to dispose the loading as shown in Fig.*B*(ii). There has been a near perfect balance as a result.

I should like some opinion of motor inertias. Fig.*C* shows the motors of two recent mills which are mechanically identical. The drives were by different manufacturers. Moments of inertia of summated motor and mill are shown. I should like to know which of those set-ups the authors consider the better, and why.

Since I have criticized the gauge control mentioned in the paper, I should like to illustrate what has been achieved using direct X-ray gauge control.

Figure *D*(i) is a record of outgoing gauge from a manually controlled five-stand tandem mill; Fig.*D*(ii) shows the same outgoing gauge when automatic gauge control is switched on to the no.1 stand of the mill; Fig.*D*(iii) shows the gauge when



B (i) *Original and* (ii) *revised arrangement of generators*

TABLE 1 Percentage of accelerating torque to full load torque for each motor

Mill	Stands 1	2	3	4	5
A	4·4%	6·4%	14·0%	24·4%	59·2%
B	6·6%	12·3%	22·5%	26·7%	58·5%

auto-control is added to the no.5 stand. Fig.D(iv) shows apparent gauge variation due to random changes in X-ray intensity.

A control of a similar kind was described in articles published by General Electric of the USA some years ago.[1–3] Since then other approaches have been made by paper mill and non-ferrous mill makers. The first application I saw on a steel mill in this country was at Ebbw Vale, which employed tension control through the mill in addition to gauge control on stand 1. This too seemed highly successful.

No originality is claimed for the Velindre system, apart from the intimate design details, but the whole scheme was conceived and installed in three weeks at a negligible cost. I have grave doubts concerning the possibility of successful gauge-meter control on such a mill.

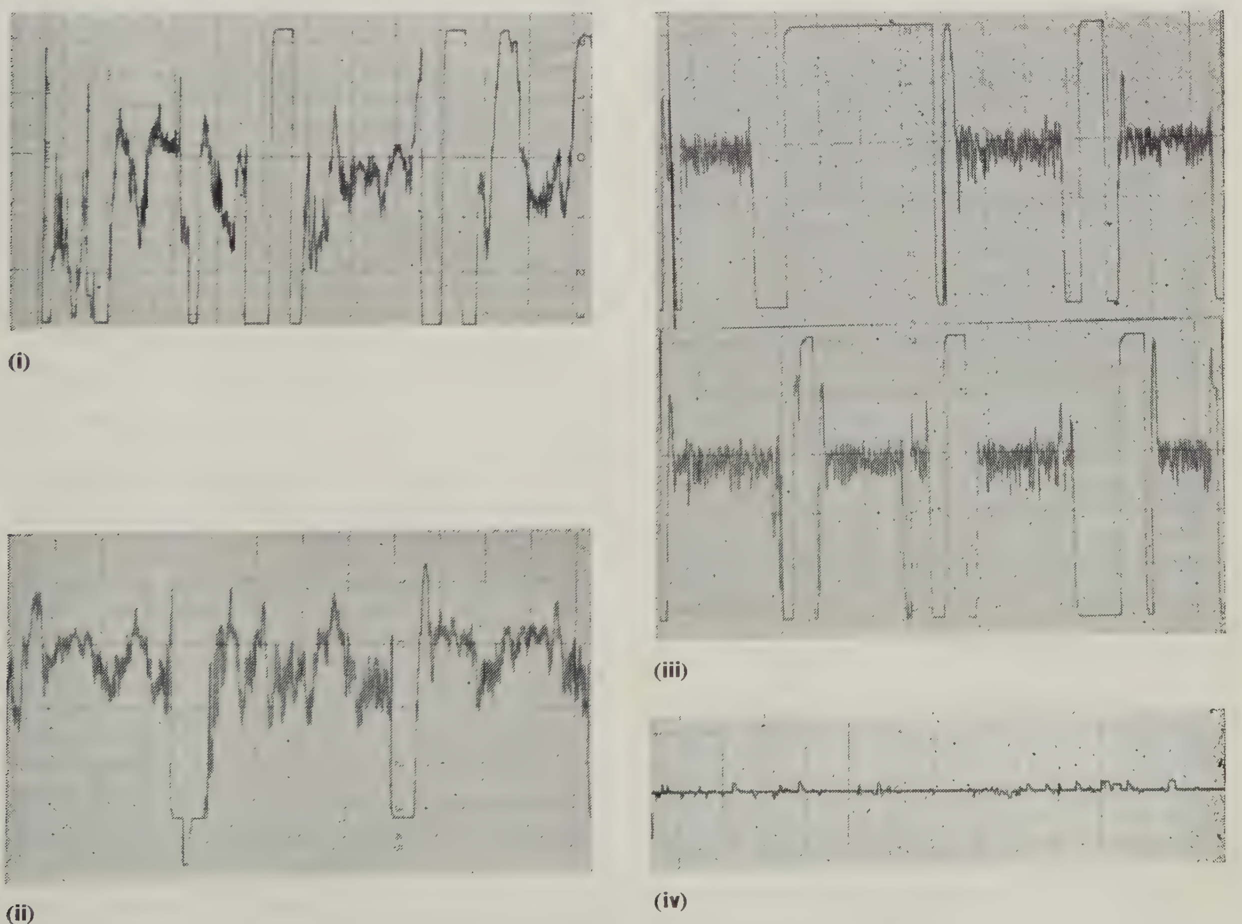
Mr **Morgan,** in reply: Referring to 'overshoot' of gauge when rolling speed is attained, this is not caused by acceleration or speed effect. As is well known, the leading end of a hot-rolled coil is thinner than the desired gauge, and it is this which gives rise to what Mr Nelsey describes as 'overshoot'. The faster a cold mill accelerates, the greater will be the length of strip between the point at which rolling speed is attained and the point on the ingoing strip where the desired ingoing gauge is reached. Until this is reached the strip emerging from the cold mill will be thinner than desired. To achieve maximum throughput and to reduce offgauge material due to speed effect, the mill should be accelerated as fast as possible; it should be the province of automatic gauge control to correct the outgoing thickness for this variation of ingoing thickness. This also emphasizes the need for effective gauge control on hot strip mills.

Mr Nelsey points out that a gauge-meter used for gauge control must be 'slugged' to iron out the effect of back-up roll eccentricities. While this is true, the problem arises from the sluggishness of response of the normal screwdown system or stand speed control and not in the speed of response of the sensor. This is not peculiar to a gauge-meter but is equally true of any other sensor, the inherent response time of which is fast enough to be sensitive to the back-up roll eccentricity.

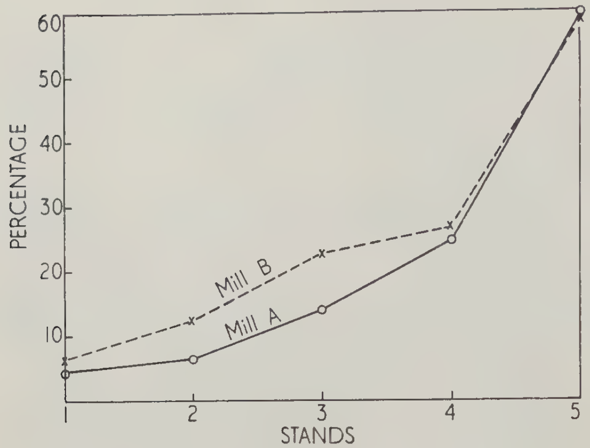
Regarding the use of differential pressure gauges with throw-away filters, this can certainly be successful where a system of planned maintenance is in operation. We agree it is difficult to ensure regular attention, but the gauge is still an advantage, even if not 100% effective, since the only other indication that the filter is due for changing is undesirable overheating of the machine.

Referring to motor inertias, a simple way of comparing the two mills quoted by Mr Nelsey is to consider the percentage of accelerating torque to full load torque for each motor for a particular set up. Using the second schedule of Table I in our paper, and taking the inertias of armatures and mills together and assuming both mills accelerate in 10 s, the percentages are set out above in Table **1**.

Shown in this way, and as all these machines are designed to develop up to two times full load torque for 15 s, it can be



D (i) *Five-stand tandem mill manual gauge control* (ii) *Stand 1 only on AGC, ½ s on 3½ s off* (iii) *Five-stand tandem mill AGC on stands 1 and 5* (iv) *X-ray gauge without strip showing random variations*



E *Percentage of accelerating torque to full load torque*

seen that none of the inertias imposes a limit on acceleration, and they are therefore of no great consequence.

However, on mill *B* attention has not been given to achieving low inertia on stands 1, 2, and 3, but only on stands 4 and 5. Table 1 figures are plotted in Fig.*E* and the discontinuity between stands 3 and 4 is apparent.

In the case of mill *A* the inertias have been chosen so that each stand inherently accelerates at the correct relative rate to maintain satisfactory interstand tension without recourse to inertia compensation. This is not the case with mill *B*, which uses inertia compensation. Both mills achieve satisfactory interstand tension during acceleration but mill *B* has this slight added complication.

Mr **Peck,** in reply: Mr Nelsey asked about the use of 50- or 400-cycle magnetic amplifiers. A great deal of discussion has taken place on this. We have mills with both 400-cycle auto self-excited and 50-cycle flux-reset type magnetic amplifiers. The characteristics of the two are such that the 400-cycle has a slight advantage in response time but there are obvious advantages if satisfactory performance can be obtained with the other system, in that the 400-cycle supply is no longer necessary. We are not sure that either is the ultimate, but that is the balance at the moment.

Mr Nelsey outlines a number of reasons for not having twin drives. These are outside the scope of the electrical manufacturer who can only supply drives which are requested, and it has been stated by mill makers in the USA that there is proved reduction in roll wear by the use of twin drives on the later stands of tandem cold mills compared with traditional pinion drives. At the moment two tandem cold mill drives with twin motors are being built in the UK, and it will be interesting to see how they work out in practice.

Referring to Mr Nelsey's question about adjustment of the respective motor characteristics in twin drives to allow for differences in roll diameters, one method is to provide a control for the operator calibrated in differences of work roll diameters. This control may either modify the speed reference or alternatively offset the speed balance circuit. One particular steel works has stipulated that the larger roll shall always be placed in the lower position, which makes the setting fairly simple. The practice on some twin drives in other parts of the world is to use fairly well-matched rolls and accept the slight unbalance of torque caused by this.

Regarding the question of the speed cone, the electrical manufacturer again is in the hands of the mill builder or user, and we often wish that these two would decide that they do not want such a large range of future schedules which may never be rolled. Undoubtedly it would ease the design of the later stand motors if a shorter speed range was required.

Is load compensation to be available to the operator or is it only under the control of somebody in the machine room or control room? That again is a matter which has been debated between users. Some say it is desirable to have a measure of load compensation inherent in the drive while others say it should not be used at all. The compromise has been adopted of allowing operators to have a small amount of compensation which they can adjust while the basic characteristics are set up by those responsible for the drive.

The optimum value of droop setting between the full speed and threading speed of a mill is adjusted so that as the mill retards, the tension does not become excessive. It is particularly necessary on a tinplate mill that tensions should not rise during retardation as there will be a danger of strip breakage, and we have found that settings which automatically change as the mill runs down from 4 or 5% at top speed to 20% at bottom speed give satisfactory results. This can be adjusted and set up to suit the operating characteristics of the mill, so that on a sheet mill a tension increase can be provided if required.

The high-speed circuit breakers have been commended. They are used because they are capable of contactor service as well, and thus dispense with the need for a line contactor.

We note Mr Nelsey's comments about the grouping of generators on the MG set. This is something which is dependent on schedules propounded when the design of a mill is first thought of, and the manufacturers can only follow the information given. The grouping is always the subject of a lot of discussion in the early stages of a contract. The advantage of using duplicate generators throughout for the stands, which permits such a readjustment of MG set grouping to be made, should be noted.

We are well aware of the importance of suiciding a mill of this sort. Suicide circuits of any strength can be designed. The difficulty does not lie so much in the efficiency of the suicide itself as switching it in and out without introducing undesirable transients, and it is something which designers are constantly seeking to improve.

Mr **G. Ovens** (McLellan and Partners): I am particularly interested in the parts of the paper dealing with the drive characteristics and in automatic gauge control, but I have found it difficult to follow the arguments leading up to the desirable drive characteristics and in finding a connexion between some of these characteristics and what has gone before. The authors say that a number of stands rolling in tandem behave almost as a critical mill, and with this I agree entirely. If we consider effects of the first order of magnitude we can say that a five-stand mill is a critical mill. The use of terms like 'over critical' and 'under critical', while of value in discussions of mathematical analyses, from which they derive their existence, are not enlightening to many; they are far removed from their literal sense and derivation, and therefore convey no meaning without being defined at some length.

There are two practical aspects concerning the effects of the operator's controls that need underlining, and I should like to have the authors' comments on their attitude, first, to variation of the screws, and secondly to variation of the field strengths of the motors.

I take, for example, a five-stand mill not only because it is something I am familiar with, but also because effects such as the speed effect are more noticeable. Moreover, it is habitually used for rolling the comparatively delicate tinplate of which the gauges shown in Table I of the paper are typical. From this table it will be clear that, apart from the first schedule, the greatest percentage reduction is made in the fifth stand, which is how the operators like it. It gives them best control of the finished product in gauge and shape by manipulation of the controls of stand 5.

Imagine a five-stand mill at speed and let us examine the effect of varying the screws on stand 5, where much of the work is done. If the screws are raised, all that happens immediately in the roll nip is a reduction in vertical compressive stress and an increase in horizontal tensile stress. This is mainly in the backward direction on the fifth stand of a five-stand mill, for the reel tension is comparatively light and is

dictated by other considerations. The work done in stand 5 is a combination of squeezing and drawing by back tension, with a little help from the reel.

In the first order of magnitude the motor power does not alter. Why should it? It can only alter if the product of flux, armature current, and speed has changed. These factors have not altered so that the effect of raising the screws has merely changed some of the motor power from rolling by compression, including the associated losses, to reduction by tension. In other words, the rolling load is reduced, the motor tries to accelerate, and is held back by the strip. Thus the tension between stands 5 and 4 rises. This immediate effect is borne out by practical observation.

It may be argued that the tension between 5 and 4 has increased, therefore the earlier stands will be accelerated: not appreciably, I think, even though the drive is generally soft. There will be a slight upward trend, but this is a second-order effect, for not only is the increased tension shared out among the earlier stands, but the percentage speed rise for a given change in tension in these stands is progressively less towards the entry end. Together they are rock steady; the rise in speed because of increase in the tension between 5 and 4 is negligible. Furthermore, the change in speed of the whole mill is negligible and the change in gauge imperceptible; this is borne out in practice. The remarkable feature of cold rolling in a five-stand mill is that raising the screws of stand 5 does not increase the gauge.

The same arguments can be applied to the other stands in the body of the mill. Within the body of the mill, moving the screws merely transfers the work from one stand to another. There is no net change in the functioning of the whole mill. The arguments do not apply to stand 1, with which the authors have dealt fully in the paper (Fig.3). That the percentage reductions in stand 1, as shown in Table I, are small seems to me to be quite a natural outcome of the phenomenon of cold rolling. A five-stand mill is a four-stand mill with the first stand acting as a back tension device for stand 2 and able to iron out irregularities in incoming hot band.

My second point concerns varying the so-called stand speed setter. Again, taking stand 5 as an example, if the motor field is weakened, the flux goes down, the voltage generated inside the motor goes down, i.e. the back emf falls and the source of power, the generator, can pump more current through the motor. The increase of current is much greater than the reduction of flux, therefore there is a net increase in torque and of power. Should not we therefore look on the stand speed setter as the tap by which the operator can cause more or less power to flow? This is in contradistinction to my first point; screw setting other than on stand 1 leaves the electrical power supplied to the mill sensibly unchanged.

When the stand speed setter is moved to weaken the field, the motor gives out more power, the interstand tension goes up, more work is done on the material by tension or drawing, and a reduction in gauge results. The increase in the speed of the motor is not to the extent shown on the stand speed setter but it does increase, and is restrained by the strip. That is why I referred to it earlier as the so-called stand speed setter; it should be called that at standstill and we should re-label it 'power controller' when the mill is at speed.

Because the motors are used in this way to control the work done in the mill, I agree in some measure with the fourth desirable characteristic which the authors have set down. I doubt whether similar adjustments can produce similar results at all speeds. This is certainly not a natural quality of a dc motor with shunt control on a variable voltage supply. All that one can say is that the adjustments should not produce surprising results, but let me emphasize that it is the inherent characteristics which are of immediate importance and not those manufactured synthetically by feedback circuits with magnetic and rotating amplifiers and clever circuitry. The inherent characteristics of the motor and, to a lesser degree, of the generator are what determine whether nor not a mill feels right to the operator.

Consideration of the so-called speed effect follows naturally from the thoughts on changing the screw setting. The speed effect is observed to have the same character, with appropriate sign, as changing the screw pressure. Thus a change of mill speed from a higher to a lower (I refrain from using 'deceleration', for this has nothing to do with rate of change of speed) is accompanied by, on stand 5 for example, an effect of raising the screws. Thus the tension between stands 4 and 5 rises, and similarly between other stands but in lessening degree towards the entry end. In a five-stand mill, where strip is comparatively delicate and where the change of speed from run to thread is large, there would be an intolerably large rise in tension if nothing were done to relieve tension as the speed falls. Usually tension is relieved by easing back on the speed setter, but this means an increase in gauge. I suggest that the screw drives should be equipped with positional control, or some form of continuous control, so that tension could be relieved by control of screw setting which, as a first approach, could be tied up with mill speed. A further step might be to control the tension by the screws in a closed-loop system. That it is possible to roll down to 0·008in both at 4000 ft/min and at 400 ft/min is well known; transition should not be difficult. I should like the authors' views on this approach to the problem which might make the duty of automatic gauge control less onerous.

I should like to conclude by referring to the first desirable drive characteristic mentioned by the authors, namely, the behaviour during acceleration. To my mind, as far as acceleration is concerned, each stand should be supplied with power proportioned to the increase in its kinetic energy; this is in fact done by the inertia compensation circuits. Clever circuitry can be of use here, feeding forward the knowledge of a transient condition. It is wrong to say that interstand tension must not vary. That may be necessary under certain conditions to maintain gauge.

Mr **Morgan,** in reply: A multi-stand tandem mill may behave as a whole as a critical mill but it does not follow that the individual stands do so. The criticality of each stand depends upon the mill set-up at the moment and will vary *inter alia* with the droop of the driving motors which, depending upon the amount of IR compensation, may vary with the particular field setting selected.

We have recordings taken on the four-stand mill referred to in the paper which show that an increase in tension between stands 3 and 4 caused by increasing the stand 4 speed setting, is accompanied by a reduction in tension between stands 2 and 3, i.e. stand 3 is under-critical. However, by observation it is clear that this is not always the case and depends upon the schedule being rolled and the precise mill setting. For these reasons it is not possible to generalize on the effect of screw or field strength changes. Each stand must be examined for each mill set-up.

Mr Ovens stated the work done in stand 5 is a combination of squeezing and drawing and if the work done by squeezing is reduced, that by drawing is automatically increased, i.e. it is a self compensating system. We do not agree with this. If it were so either a screw change or a field setting change would have the same effect. One of the reasons why raising stand 5 screws does not have so large an effect on outgoing gauge as might at first be expected is due to the increase in tension between stands 4 and 5, not only reducing the roll force in stand 5, but similarly reducing the gauge of the strip issuing from stand 4. This tension change may or may not be reflected back to earlier stands, depending on the criticality of each stand. Roll flattening can also play a part.

Rather than consider the effect on individual stands of screw or field setting changes, it may be clearer to consider a multi-stand mill as a whole. If the input to stand 1 is maintained constant and the outgoing strip velocity from the last stand remains constant, then, under steady state conditions, any change in individual stand speed or screw settings cannot affect the outgoing gauge and can only alter the relative stand loadings. Conversely, altering the input to the mill or altering the outgoing velocity will produce a proportional change in gauge. If, for example, the input to the mill is reduced by 1%

and the outgoing velocity is maintained constant, under conditions of equilibrium the outgoing gauge will be reduced by 1% and this is absolute.

The statement that gauge and shape are controlled by manipulation of the controls of stand 5 requires some qualification. In several tandem mills known to the authors, gauge is maintained mainly by the trimming of the speed of stand 1 and only to a much lesser extent by adjustment of the speed of stand 5, the interstand tension being kept constant by adjustment of the screws. This applies whether the mills are on manual or automatic control. Shape is usually controlled by adjusting the coolant sprays or trimming one of the screws on the appropriate stands.

The only difference between inherent characteristics and synthesized characteristics, so far as the operators are concerned, arises from differences in the time constants of the two systems under transient conditions. If these are roughly the same, the operators cannot tell the difference.

Referring to the speed effect, this operates from about 800–1000 ft/min up to top speed. The effect occurs on all mills, but we agree is more serious when rolling tinplate gauges because the thin hard strip can withstand but little elongation without breaking. Thicker strip can stand more elongation and therefore accommodate greater changes in interstand tension. The tension changes arising from the speed effect are of the correct sign to oppose gauge changes produced by the speed effect. For this reason it can be an advantage to have fairly stiff drives on mills rolling thicker material. If this were attempted on tinplate gauges, the mill would become unmanageable.

The statement that tension is usually relieved by easing back on the speed setter requires qualification. This is certainly not always so. Fast mills are generally set up to run on gauge at the run speed and the heavier gauge at intermediate and thread speeds accepted. The droop of the machines is arranged to be as hard as can be tolerated at the low speeds so as partly to counteract the speed effect. Even so, droop as great as 25–30% at thread speed is not uncommon.

While it may eventually be possible to accelerate a tinplate mill from thread to run speed without changing gauge, we do not agree the 'transition should not be difficult'. It is too difficult to achieve by practicable means in the present state of the art. Modern mills are required to accelerate at rates in excess of 400 ft/min/s and owing to the time constants involved constant gauge could only be achieved by open loop control and considerable accuracy under these transient conditions would be necessary.

There are at least three cold mills in this country where some or all interstand tensions are automatically controlled in a closed loop by adjustment of the screws, and there is no doubt this is beneficial. On those mills where this is applied between all stands it plays an important part in the actual control of gauge. This is because the direction of movement of the screws to maintain constant tension acts in the right direction to counteract gauge changes due to speed changes.

The time constants involved, however, and rapidity of acceleration do not make it possible to hold gauge absolutely while the mill is coming up to speed.

An alternative approach would be to reduce the acceleration rate to enable gauge control to be effective without recourse to the complications of open loop control. If this solution were adopted expensive multi-armature low-inertia drive motors would no longer be necessary, but the reduction in possible throughput due to the increase in time to reach the rolling speed would have to be accepted.

Mr **A. P. Baines** (English Electric Co. Ltd): Mr Nelsey mentioned that with the gauge-meter system of gauge control, roll eccentricity is not only not corrected for by the gauge-meter but can be accentuated. This is most important, as it is the opinion of many that by applying the gauge-meter system a fast method of gauge control is obtained whereas in fact roll eccentricity can limit the realization of a fast system.

Mention is made of a system proposed by the Russians which, the authors state, does not correct for roll eccentricity. This is so, but surely the importance of the Russian approach is that a method is proposed which is not only not limited in speed of response by roll eccentricity problems but is also not limited in its corrective action by system delays. An interesting point in this system is the use of a computer which determines the corrective action to be fed forward. Surely it would be possible to extend this system so as to allow the computer to determine corrections which should be made during the acceleration period to obtain correct gauge during this period.

No mention has been made by the authors of the use of rectifier-fed drives for cold mills. I feel that brief mention of their use and possible advantages and disadvantages would enhance the paper, particularly as several such mills are in operation both in this country and on the continent.

Mr **Morgan,** in reply: We think there may be a danger of confusion here. The response time of the gauge meter itself is fast but the time constants of the screwdown motors and control gear together with the mechanical arrangements of the gearing and screws make it impracticable to take advantage of the gauge-meter output and move the rolls up and down fast enough to correct for roll eccentricity, or similarly by trimming the stand speed.

In such a system if the eccentricity frequency approaches any system resonance, instability sets in and the eccentricity can become amplified, but this is not the fault of the gauge-meter itself.

Correction of roll eccentricity can only be achieved by an open loop arrangement such as that proposed by the Russians which can send a signal ahead of the measuring point.

It should be able to correct incoming gauge variations caused by roll eccentricity in the hot mill, and also that by stand 1 of the cold mill. The limitation, however, is not the speed of detection of gauge error and calculation of the corrective action to be taken at a point ahead, but the speed of response of the stand speed adjustment by means of which correction is to be applied. In high speed tandem mills it is doubtful if such an adjustment can be made fast enough by conventional means to correct for roll eccentricity.

As we have said in reply to Mr Ovens, we agree that an open loop system is probably necessary to counteract completely the speed effect in high-speed tandem mills, and we agree with Mr Baines that a development of some such system as that proposed by the Russians might be suitable.

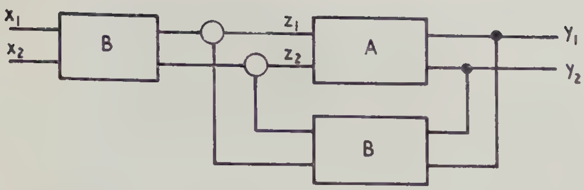
Mr **Peck,** in reply: Mr Baines rightly draws attention to our omission of any reference to the use of mercury-arc rectifiers for driving a mill of this sort. This was chiefly due to the feeling that the paper had already reached sizeable proportions. Today any Ward-Leonard type of application can be performed with equal or greater facility by using the grid-controlled mercury-arc converter in place of the exciter-generator chain. In this country for drives of substantial rating, the multi-anode pumpless steel tank mercury-arc converter with its attendant advantages of low back-fire rate and easy adaptability to circuit requirements (e.g. number of phases, grouping, etc.) is invariably used.

For a tandem cold mill, cross-connected converters are essential as continuous control throughout the whole range from full rectification to full inversion (i.e. regeneration) is needed.

Modern grid control and phase-shifting circuits together with their controlling amplifiers are completely static and have an exceedingly high rate of response. It is in fact necessary to ensure that the rates of change of main loop current are kept within the commutating ability of the drive motors.

In the case of a tandem cold mill, which is non-reversing, the invertor capacity can be less than that of the rectifier unless the retardation rates stipulated for quick stopping preclude this.

The main problems in the use of mercury-arc converters do



F *Non-interacting system*

not lie in the realm of either their reliability or their performance, which are now well proven, but in the limitations of the supply system. These are threefold:

(i) the effect of harmonics on the supply system and other apparatus connected to it
(ii) the effects of peak loads on the system voltage, due to the reactive load imposed by the converter when operating at low voltages, and
(iii) the effect of system disturbances on the drive.

Points (i) and (ii) have been well dealt with elsewhere[4] and with the system capacities available today do not usually impose a limitation. Point (iii) relates to the ability of the converter regulating system to maintain the required drive voltage or speed in the face of transient dips in the supply voltage. These can be appreciable, for instance during the brief time of clearance of a remote circuit fault. While an MG set would ride through such an occurrence it could be beyond the range of regulation of the converter control system, and the drive would have to be tripped out and brought to rest by dynamic braking with possible consequent strip breakage. This aspect must not be exaggerated however, and experience on rectifier drives of various kinds installed to date indicates that a shut-down due to supply system troubles is rare.

The advantages of mercury-arc converters are as follows:

(i) they are entirely static and maintenance is reduced to a minimum
(ii) they are more efficient than the equivalent MG set both on load and as regards standby losses
(iii) whereas the cost of the drive itself may be a little greater than that of the equivalent motor-generator set alternative, the installation and building costs will be appreciably less
(iv) mercury-arc converters do not add to the supply system fault capacity, and
(v) even better control response is obtainable with them than with the motor-generator system.

The use of mercury-arc converters has been almost universal for continuous hot mills for some time. Today they are being applied to reversing hot and cold mills, temper mills, and tandem cold mills, as well as to mill auxiliary drives. In fact, application is only limited by users' preference and supply system restrictions.

WRITTEN CONTRIBUTIONS

Mr **W. L. Marks** (Davy-United–AEI, Steelworks Automation Unit) wrote: The authors have produced a good paper qualitatively defining the problems of control particularly of multi-stand tandem mills. The interaction of such a plant is shown by a simple step-by-step procedure detailed in Fig.3 of the paper. The mode and sequence of operation of the mill is brought into sharp focus.

The mathematics, quantitatively dealing with multi-dimensional plant such as a multi-stand strip mill, was developed by J. O. Cruikshank,[5] and has been applied to the control of such plant by Kavanagh,[6] and Phillips,[7] in recent years.

The method is to define the multi-dimensional plant by a matrix transform and the art of the engineer lies in synthesizing a controller, also defined by a matrix transform, which may be used in the feedback path of the plant in order to comprise a system. This system of plant and controller may be designed to achieve a desired overall characteristic. One such characteristic is non-interaction which will assist in the control of the plant.

The paper indicates what the elements of the matrix are to be composed of. It is interesting to note, in the step-by-step procedure of the synthesis of the method of control, the insistence on non-interaction or isolation of stages. Where such non-interaction is not possible by the guiles of feedback and control, the authors rightly require it as a necessary prerequisite.

The procedure rendering a simple two input–two output interacting system non-interacting is outlined below.

Consider a plant A having the matrix transform, where

$$Y = AZ$$

$$A = \begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix}.$$

Include the plant A in the system of Fig.F, with a controller B, where

$$B = \begin{vmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{vmatrix}.$$

It can be shown that the overall system is given by

$$\frac{Y}{X} = AB(I - AB)^{-1}$$

where $AB\ (I - AB)^{-1}$ may be considered to be the overall system transfer matrix S for a non-interacting system

$$S = \begin{vmatrix} s_{11} & o \\ o & s_{22} \end{vmatrix}$$

where $S = AB\ (I - AB)^{-1}$.

Hence the controller

$$B = A^{-1}\ S\ (I - S)^{-1}.$$

On simplification

$$B = \frac{1}{a_{11}\,a_{22} - a_{12}\,a_{21}} \begin{vmatrix} \dfrac{s_{11}\,a_{22}}{1+s_{11}} & -\dfrac{s_{22}\,a_{12}}{1+s_{11}} \\ -\dfrac{s_{11}\,a_{21}}{1+s_{22}} & \dfrac{s_{22}\,a_{11}}{1+s_{22}} \end{vmatrix}.$$

The controller B is defined in terms of the plant A and the specified system response S. Constraints are necessary about S in order to achieve realizability, and hence realizability criteria may be built up which require satisfaction. These constraints implied or imposed on S are reflected in the plant A, and hence it is necessary for the synthesis procedure of the controller B to keep in step with the procedure of defining the plant A.

The elements a_{11}, a_{12}, etc. of the matrices are Laplace transforms of the various control elements, speed, screwdown, etc., and the paper gives a realistic indication as to what these elements should be, and where to look for them. As an example let

$$A = \begin{vmatrix} \dfrac{1}{1+p} & \dfrac{4}{1+2p} \\ \dfrac{1}{1+3p} & \dfrac{1}{1+2p} \end{vmatrix}$$

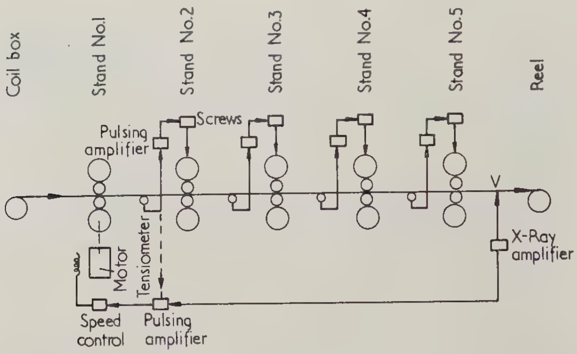
where the overall non-interacting system is required to be

$$S = \begin{vmatrix} \dfrac{1}{1+p} & o \\ o & \dfrac{1}{1+2p} \end{vmatrix}.$$

The controller B may be synthesized as

$$B = \begin{vmatrix} -\dfrac{(1+p)\,(1+3p)}{6\,(1+\frac{1}{3}p)\,(1+\frac{1}{2}p)} & \dfrac{2\,(1+p)^2\,(1+3p)}{3\,(1+\frac{1}{3}p)\,(1+\frac{1}{2}p)\,(1+2p)} \\ \dfrac{(1+2p)^2}{6\,(1+\frac{1}{3}p)\,(1+p)} & -\dfrac{(1+2p)\,(1+3p)}{6\,(1+\frac{1}{3}p)\,(1+p)} \end{vmatrix}.$$

Approximations may be used to simplify the form of the controller B, and the final controller in a practical situation may



G *Schematic arrangement of auto gauge/tension control, five-stand mill*

not be as straightforward as the algebra indicates. Nevertheless, the basic idea presented here is true for such systems.

Mr **Morgan,** in reply: There appears to be an arithmetical error in Mr Marks' contribution. Whereas we agreed that

$$S=AB\ (I-AB)^{-1}$$

then surely

$$B=A^{-1}S\ (I+S)^{-1}$$

which leads to

$$B=\frac{1}{a_{11}\,a_{22}-a_{12}\,a_{21}}\begin{vmatrix} \dfrac{s_{11}\,a_{22}}{1+s_{11}} & -\dfrac{s_{22}\,a_{12}}{1+s_{22}} \\ -\dfrac{s_{11}\,a_{21}}{1+s_{11}} & \dfrac{s_{22}\,a_{11}}{1+s_{22}} \end{vmatrix}.$$

This, however, in no way invalidates Mr Marks' argument that once the natural or uncontrolled behaviour of the mill is known the synthesis of the gauge control can be undertaken.

The problem is not, however, quite so straightforward as might appear, for although for a small range of control the mill equations and coefficients can be taken as about constant they nevertheless change depending upon the order being rolled, i.e. they are dependent upon strip width, steel quality, rolling lubricant, and the particular mill set-up for the overall reduction required. The difficulty of extracting these coefficients will be apparent.

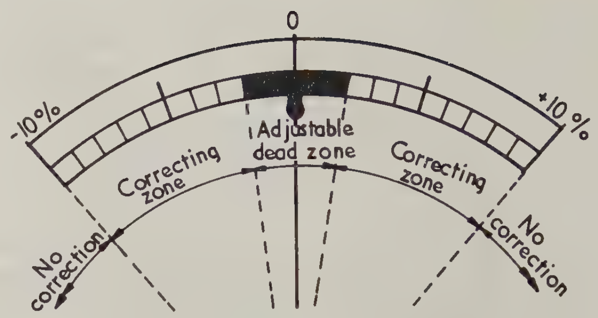
A control scheme is soon limited by financial as well as technical considerations, and performance has to be sacrificed to simplicity and versatility. The problem of maintenance must also be taken into account.

When thinking along the lines suggested by Mr Marks, one is led to consider self-optimizing systems but such systems require to learn and must be provided with large memories to ensure they approach the optimum at the start of rolling.

Mr **A. W. Ellis** (Richard Thomas and Baldwins Ltd) wrote: The paper comments broadly on the importance of mill motor compounding, but it should be emphasized that the degree of compounding should be related to actual rolling loads, and not to the full load current values. It has been found at Ebbw Vale that the correct settings of the compounding controls can reduce the changes of interstand tension during steady state conditions, and to a lesser extent during acceleration and deceleration when inertia compensation becomes predominant.

While agreeing with the authors' comments concerning designs of commutator covers, we should like to mention that as far back as early 1955, the problem was resolved, in conjunction with manufacturers, by designing one-piece covers, located by tapered dowels in the base and secured by pivoted hand nuts.

Reference was made in the paper to the use of inertia compensation on winding reels, even to the extent of providing a reversal of torque during deceleration to maintain constant reel tension. This is applicable if the reel is of the type which is



H *X-ray gauge meter*

expanded hydraulically. If, however, a Klein-type reel is used, it has been found necessary at Ebbw Vale to decrease the amount of inertia compensation during deceleration to avoid the reel collapsing.

The problems of gauge control and three alternative solutions put forward by the authors are most interesting. A further solution has been adopted on the five-stand tandem cold-reduction mill at Ebbw Vale.

Various methods of AGC were examined and studied in operation, but it was considered that most of the systems reviewed were extremely complicated, and indeed expensive. It was therefore decided that the electrical engineering department should design, manufacture, and install a gauge sampling system which would initiate correction by means of pulses based on the principles shown in Figs.*G* and *H*. The electronic equipment has been designed for accommodation in standardized chassis as illustrated in Fig.*I*, and designed for maximum reliability and easy replacement under 20-shift working conditions. Transistors are used wherever applicable.

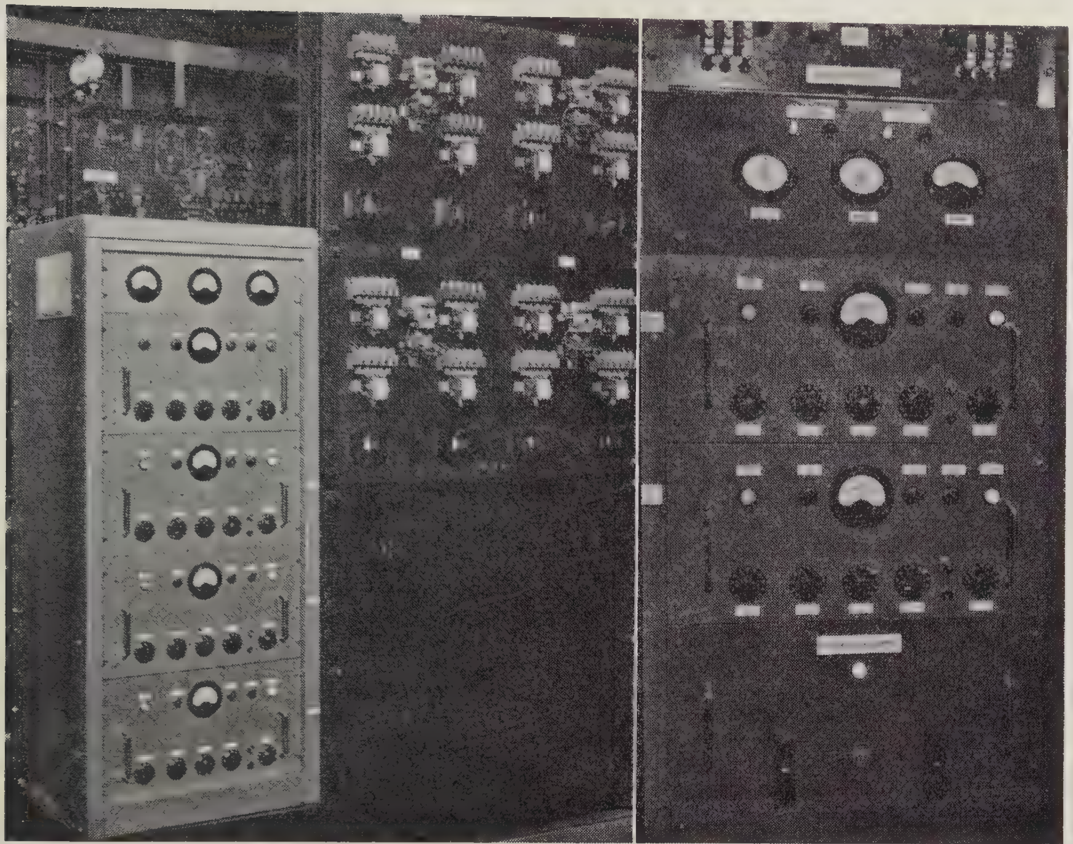
As can be seen from Fig.*H*, the control covers a total range of $\pm 10\%$ of the preset gauge, and of this the inner dead band covers an adjustable area of 1–2%, and this is the area within which no control is desired. The control is then applied to correct errors in gauge up to the limit of $\pm 10\%$. Beyond this range, it is considered that the mill set-up is likely to be faulty, and the equipment then cuts out automatically and a signal is given so that the set-up can be brought within range manually.

The electrical circuit is so arranged that the length of each individual correcting pulse is a function of the error signal, in that the larger the error the longer the correcting pulse, while the overall pulse time can be preset to the desired value which will give the maximum correction without instability. The adjustment of the space time between pulses is also possible, and can be preset to allow the correct sampling time.

It should be noted that there is no automatic change of the sampling time in line with the speed of the mill, because it has been found that the advantages to be gained from this complication are relatively small. In fact, the whole system is based on a policy of doing automatically what the operator would normally do without such equipment. In addition, a series of protective arrangements to ensure that the equipment will automatically fail to safety in the event of faulty operation is included, and this leaves the mill control in such a condition that the operator who receives a warning of such an occurrence can take over and carry on with normal manual operation which can over-ride the automatic system at all times.

The AGC was installed successfully in March 1960 and operated from a flying micrometer as an interim measure, pending delivery of a Daystrom X-ray gauge. The installation of an X-ray gauge was considered necessary to overcome the well known inaccuracies which occur when flying micrometers are operated at high strip speeds. The Daystrom gauge has now been in service for seven months with most gratifying results. Twelve months continuous operating experience with the AGC has resulted in a 15% reduction of the amount of off-gauge material produced.

Concurrently with the development of the AGC, an automatic tension control system was developed and installed



I *Two examples of standardized chassis*

between all stands, as shown on Fig.*G*. The ATC uses the same pulsing technique as developed for the AGC, but the signals are obtained from the tension measuring rolls. Operators are provided with tension setting controls, as shown on Fig.*J*, and the equipment maintains the desired value within a controlled zone.

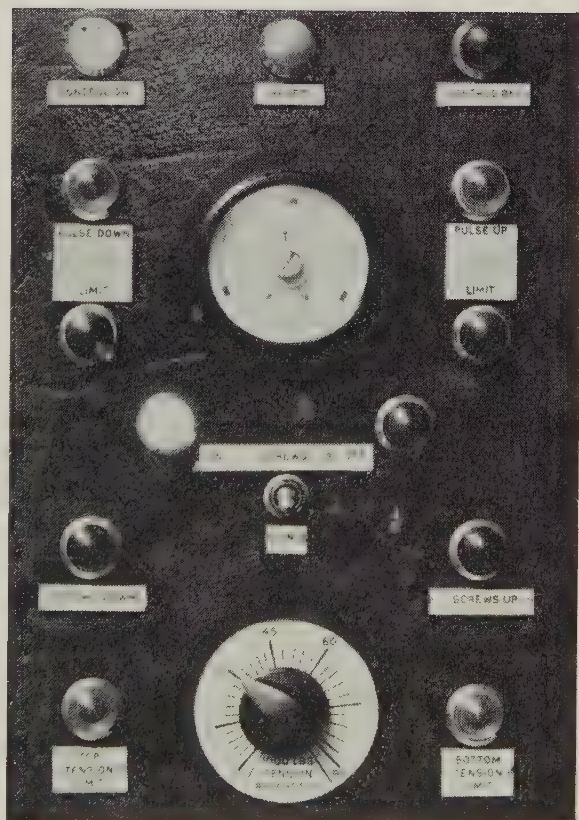
Great benefits have accured from this development, including smoother running of the mill, reduction in operator fatigue, and a 74% reduction in the number of roll changes caused by loss-of-tension wrecks. Although these particular wrecks occur at infrequent intervals, the rolls themselves may be severely damaged and the cost of reclamation may be very high.

Further benefits have resulted owing to the complementary nature of the two systems, in that movement of the screws to regulate tension is in the correct direction to maintain gauge. This results in increased mill stability, which has been proved in practice, as it is found possible to leave the automatic equipment in operation at all times, except during the initial warming-up period immediately following a roll change.

Similar equipment has been installed on the four-stand cold-reduction mill, but, due to limitation of existing mill equipment, it was found necessary to substitute screw control in place of speed control on stand 1.

Mr **Morgan,** in reply: We support Mr Ellis's remark about compounding. The criticality of each stand depends upon the amount of IR compensation used and the degree of field weakening.

The maintenance of constant interstand tension by control of the screws is undoubtedly the right way to tackle it since, as Mr Ellis points out, the movement of the screws to maintain constant tension is in the correct sense to oppose changes of gauge due to the speed effect. For that reason this form of constant tension control must of itself make a substantial contribution towards the control of gauge. Due to the time



J *Tension setting controls*

constants, however, there must be a lag under the dynamic conditions occurring during acceleration and completely accurate gauge during acceleration can only be realized by some form of open loop control or pre-programming.

A somewhat similar arrangement of gauge control has been installed on the four-stand mill referred to in the paper. At the moment constant tension is used only between the first two stands but will soon be extended to all the stands.

Adjustment of stand speed is achieved by trimming the series exciter in the main drive motor fields. This has the considerable advantage of automatically making the amount of correction to speed achieved by each equal pulse a fixed *percentage* of mill speed. In addition, the amplitude of the pulse is made proportional to the gauge error, thus enabling the mill to find gauge as quickly as possible.

On the first attempt a range of correction to stand-1 speed of $\pm 5\%$ was used, but this proved to be inadequate and has now been modified to $\pm 10\%$.

The use of a fixed sampling rate due to the small gains offered, rather than one proportional to mill speed, is open to question. It is advantageous to use the highest sampling rate compatible with stability and reasonable maintenance, and the cost of such an arrangement need not be excessive.

Mr **K. K. Schwarz** (Laurence Scott and Electromotors Ltd) wrote: With respect to the discussion on the merits of using higher frequencies than supply frequencies, this was raised at a discussion[8] in connexion with a paper by Ovens and Dodd.[9]

I should like to ask Mr Peck what power level and frequency is used for the equipment illustrated in Fig.6 in the paper showing magnetic amplifiers feeding the Ward-Leonard generator fields direct.

Mr **Peck,** in reply: Reference has already been made in the reply to Mr Nelsey about the supply frequency used for magnetic amplifiers on the drive described. The rating of the 400-cycle amplifiers for the stand generators is about $2\frac{3}{4}$ kW for the forward unit and half this rating for the reverse unit. The former has a 100% voltage margin above this rating for forcing and the latter a somewhat lesser margin.

Mr **H. Neal** (McLellan and Partners) wrote: Some of the features of the four-stand mill claimed as being original were developed in this country in 1948.

On the five-stand mills at The Steel Company of Wales works at Trostre and Velindre, the mill supervisory control panels are situated so that a full view of the motor room is obtained.

Also, on both these mills the method of cabling to the mill-operator controls is similar to that described in the paper and, on the first of them, was strongly opposed by the American mill suppliers. I am pleased to hear that these features are still up-to-date.

Mr **Morgan,** in reply: We do not claim originality either for a control panel which is in view of the machines controlled or for running cables from controllers and motors in conduits to intermediate terminal boxes.

The five-stand mills to which Mr Neal refers have motor rooms. The four-stand mill referred to in the paper has not, all the control gear and indicating instruments being situated in a basement a short distance from the mill and the instruments duplicated in the control pulpit.

The cabling for the control at Trostre is carried out in 16-core 7/0·029 VIR cable, one spare 16-core cable being run per stand. Nearly all the spare cores are now in use because of fractured cores resulting from the movement of the operators' cabinets and are soon to be replaced. On the mill referred to in the paper, this wiring has been carried out in flexible PVC cable and a considerable length of straight vertical conduit is arranged immediately above the cabinets to give ample space for movement of the cables. At the design stage we were a little apprehensive there might be some vibration of the conduits but these fears proved to be groundless. We anticipate a long trouble-free life from this arrangement.

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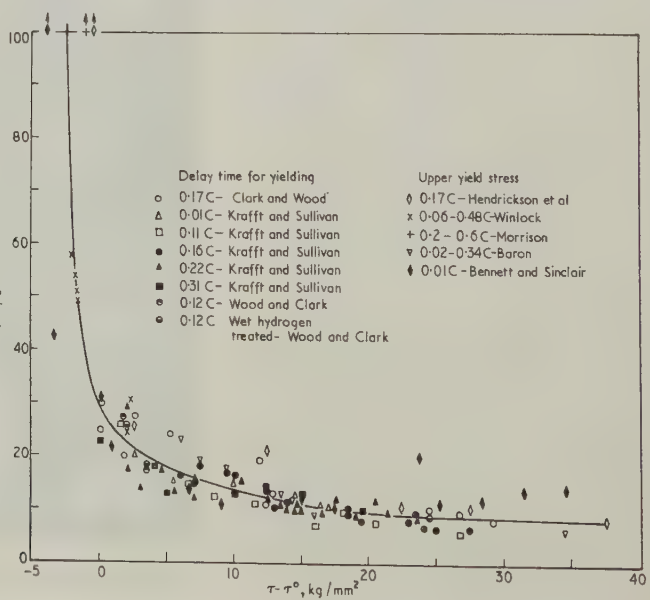
'On the mechanism of yielding and flow in iron'

In the paper of this title by Mr Hans Conrad, published in the August 1961 issue of the *Journal* (vol.198, pp.364–375) Fig.4 as printed is incorrect. The correct figure is printed here.



4 *Effect of shear stress on the activation volume v* for initial yielding in iron and steel*

NEWS | *Announcements and News of Science and Industry*

THE IRON AND STEEL INSTITUTE

Annual General Meeting 1962

The Annual General Meeting of the Institute will be held in London on **Wednesday** and **Thursday, 2** and **3 May 1962.** Technical sessions will be devoted to refractories for new steelmaking processes, and methods of measurement and improvement of productivity in iron and steelworks. Full details will be announced later.

The annual dinner for members will be held on the evening of Wednesday, 2 May.

Joint meeting with the Institute of Fuel

As previously announced, a joint meeting has been arranged with the Institute of Fuel at the Institution of Civil Engineers, 1–7 Great George Street, London SW1, on **Wednesday, 14 February 1962.** The theme of the meeting will be 'Fuel and energy for various steelmaking processes'; details of papers to be discussed were given on p.191 of the October 1961 issue of the *Journal*.

NEWS OF MEMBERS

Dr **W. O. Alexander** (*Hon. Member of Council*) has been appointed technical director of Foseco International Ltd, with effect from 1 January 1962.

Mr **R. H. Barrott** is assistant manager, east bank, of the billet finishing department of Samuel Fox and Co. Ltd.

Mr **W. M. Fern** is now deputy quality control manager at Colvilles Ltd.

Mr **H. P. Forder** has been elected junior warden of the Cutlers' Company.

Lord Dudley Gordon has resigned as chairman of Hadfields Ltd, but will remain on the board as an ordinary director.

Mr **V. H. Guy** has left the British Iron and Steel Research Association to take up an appointment with Pressed Steel Co. Ltd, Oxford.

Mr **P. E. Holloway** (*Member of Council*) has been appointed chairman of the Lancashire Steel Corporation Ltd and its principal subsidiaries. He has resigned as managing director of the Lancashire Steel Manufacturing Co. Ltd.

Sir **John James** (*Hon. Vice-President*) has retired from the chairmanship of the Lancashire Steel Corporation Ltd and from the chairmanship of its principal subsidiaries.

Professor **G. Letendre** was recently elected honorary member of the Société Française de Métallurgie.

Mr **B. Patrick** has graduated B.SC.(HONS.) in metallurgy from Nottingham University and is now with Appleby-Frodingham Steel Company.

Mr **A. G. Pearson** has transferred from South Wales laboratories of BISRA to Sheffield, as head of steelmaking laboratories under Dr J. Pearson.

Dr **T. V. Philip** has left the Crucible Steel Company of America on his appointment as senior researcher in metallurgy with the SKF Industries Inc., Research Laboratory, Philadelphia, Pa., USA.

Sir **Peter Roberts** has been elected chairman of Hadfields Ltd.

Mr **H. Smith,** chairman and joint managing director of British Ropes Ltd, has joined the board of The United Steel Companies Ltd.

Monsieur **Lucien Wahl** is now with the Société d'Electro-Chimie d'Electro-Métallurgie et des Acieries Electriques de Ugine, Lyons, France.

Obituary

Joseph Francis Begley (*elected* 1960), of Hatch End, Middlesex, on 10 September 1961.

William Somerville Dobie (*elected* 1953), of Crosby, Scunthorpe, Lincolnshire, in July 1961.

Alexander Mackay (*elected* 1902), of Banbury, Oxfordshire, on 25 June 1961.

Robert Anthony Owen (*elected* 1957), of Scotby, near Carlisle, Cumberland, in 1961.

BRITISH IRON AND STEEL RESEARCH ASSOCIATION

A simplified method of measuring grain size

Various elements are used to control grain size, which is an important factor in determining the characteristics of finished steels. The most widely used is aluminium, which inhibits grain growth by raising the grain coarsening temperature of steels. An investigation to determine the percentages of aluminium which will give effective grain control and to find the optimum method of addition has been carried out by the steelmaking division of BISRA.

From this it has been established that grain coarsening temperature rises as the aluminium content is increased, and reaches a maximum point when the aluminium content is 0·04%. If consistent production of fine grain size is to be ensured, the aluminium content must not drop below a minimum of 0·01%. It was also established that the moulds and pouring trumpets are the most effective points at which to make aluminium additions to molten steel, the aluminium losses here being smallest.

An interesting conclusion drawn from these tests is that the measurement of aluminium content of a steel provides a reliable, quick, and less expensive alternative to the McQuaid-Ehn Test for evaluating grain size. Further information is available from the Information Officer, BISRA, 11 Park Lane, London W1.

Improved wire cooling on a new capstan

Any increase in the maximum speeds and outputs of machines drawing high-tensile steel wire must be accompanied by a corresponding improvement in the cooling efficiency if the loss in ductility which results from drawing at elevated temperatures is to be avoided. Experimental tests have shown that improvements in speed of the order of 30% can be gained by preventing the formation of rust deposits on the internal surfaces of the capstans.

Further improvements may be obtained by also incorporating the new 'narrow gap' capstan design that has been evolved by BISRA. With this the cooling water is passed through a narrow annular channel between the drawing ring and a stationary inner cylinder. This ensures that the water flow is turbulent which brings about efficient heat transfer. During pilot plant trials it has proved possible to achieve a 40% increase in the production rates of heavy gauge wire with a corresponding increase of 20% for the finer gauges.

This design has the advantage that it can be fitted to most existing machines with relatively little modification. Further details are available from the Information Officer.

BRITISH CONFERENCE ON AUTOMATION AND COMPUTATION

Annual General Meeting

At the first Annual General Meeting of BCAC held at the Institution of Electrical Engineers, on Wednesday, 27 September 1961, the Chairman, Sir Walter Puckey, recalled that some 12 months ago BCAC had been reconstituted in its present form, and he then presented the annual report of the Executive Committee on the year's work. Of particular interest had been the setting up of informal panels of interested experts concerned respectively with education and training, foreign relations, public relations, and research and development.

The following honorary officers and executive committee for 1961–62 were elected:
Chairman Sir Walter Puckey; *Vice-Chairmen* J. F. Coales, O.B.E., Prof. G. D. S. MacLellan, and C. Mead; *Honorary Treasurer* S. M. Rix; *Honorary Secretary* F. Jervis Smith.
Executive Committee: The honorary officers and S. W. Adey, Dr E. H. Bateman, E. C. Clear Hill, J. Cooper, D. Du Pre, W. C. F. Hessenberg, O. D. Jordan, D. Macdougald, Sir Charles Norris, Dr J. M. S. Risk, T. G. P. Rogers, and G. M. E. Williams.

Copies of the Annual Report of BCAC may be obtained on request from the Honorary Secretary, c/o The Institution of Electrical Engineers, Savoy Place, London WC2.

Proceedings of first IFAC conference, Moscow 1960

The four volumes of the proceedings of the first meeting of the International Federation of Automatic Control held in Moscow last year have been published by Butterworth and Co. Ltd, 88 Kingsway, London WC2, price £45 per set, or £12 for each separate volume. Titles of the volumes are Theory (1 and 2); Components (3); and Applications (4). Further details are available from the publishers.

BRITISH IRON AND STEEL FEDERATION

New appointments

The British Iron and Steel Federation has announced the following appointments:
Director, BISF E. W. Senior, C.M.G. (*Hon. Member of Council*)
Managing director, BISC Ltd J. B. Cowper (BISC is the industry's main central trading organization). Mr Cowper holds this post in addition to that of financial director of the Federation.

Assistant directors, BISF J. Driscoll (economics) (*Member*), L. J. Gollop (statistics), B. S. Keeling (training) (*Member*), A. H. Mortimer (commercial).
Secretary, BISF J. M. K. Donohue (*Member*).

METALLURGICAL SOCIETY OF AIME

New membership classification of Fellows

The Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers has been authorized by the board of directors of AIME to establish a Fellow membership classification.

The step is a special recognition to be bestowed upon selected members of the Society who 'have won recognition for outstanding or notable contributions in some

phase of metallurgy'. To be named, a member 'must have attained distinction as an eminent authority in some aspect of the broad field of metallurgy', and must have been a member of the Society for at least five years.

Election to Fellowship will be by the Society's board of directors, with not more than five to be named in any year. A maximum of 100 living Fellows has been set. To initiate the new grade, a maximum of 20 are being selected this year. Thereafter, the limit of five will be in effect. Fellows will establish their own procedures for the administration of their affairs.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

Name change

The name of the American Society for Testing Materials has been officially changed to the *American Society for Testing and Materials*. In announcing this change, ASTM president Miles N. Clair said that the inclusion of the word 'and' in the Society's name placed added emphasis on the Society's research work in seeking knowledge of the nature of materials.

INSTITUTION OF MINING AND METALLURGY

President-elect

J. B. Simpson, A.C.S.M., M.I.M.M., M.I.MIN.E., has been elected president of the Institution of Mining and Metallurgy for 1962-63. He will take office in May 1962 in succession to A. R. O. Williams, O.B.E.

EDUCATION

Blocks and sandwiches

The rapid development of the technical training programme is illustrated by the Minister of Education's latest edition of list 182, *List of sandwich courses and block-release courses* (HMSO, 6*s*), recently published by the Ministry, which lists more than three times as many block-release courses for 1961–62 compared with 1960–61.

The new list gives particulars of the 374 sandwich courses (332 last year) and of the 138 block-release courses now being offered at colleges of advanced technology and technical colleges. Courses range from all branches of engineering and chemistry to the newer avenues of study such as electronics, rubber technology, and business studies. About a third of the sandwich courses now available lead to the award of the diploma in technology or to a university degree, and a similar proportion to higher national diplomas.

Both sandwich and block-release courses comprise periods of industrial training and periods of full-time college attendance, undertaken alternately. In the block-release course the proportion of time spent in college is less than for a sandwich course.

A sandwich course must include more than 18 weeks college attendance for each year of the course. The definition of a sandwich course has, however, been modified in the current list to include not only courses in which periods of five or six months in industry alternate with similar periods in college, but also other types of course in which, for instance, a full year's study in industry occupies the second or third year of a four-year course.

New residential hall at Stewarts and Lloyds

A residential hall with accommodation for 65 students was recently opened at Stewarts and Lloyds Ltd, Corby, for students employed by the company. The basic accommodation unit is a bedroom-study with full toilet facilities, and the hall includes games room, sitting rooms, sick bay, dining room, garage, and a tennis court. The total cost of the hall was about £150000.

City and Guilds publications

A list of publications of the City and Guilds of London Institute is available from the Publications Department, 76 Portland Place, London W1. Requests for the leaflet should be marked 'Institute Publications' and a stamped and addressed envelope should be enclosed.

CONTRIBUTORS TO THE JOURNAL


H. D. Morgan *P. E. Peck*

H. D. Morgan, M.I.E.E. – Chief electrical engineer, The Steel Company of Wales Ltd, Steel Division, Port Talbot.

Herbert Dickson Morgan was educated at Charterhouse and Faraday House Schools. During the 1939–45 war he served first with the Royal Artillery and later as senior experimental officer at the Anti-aircraft Command Trials Establishment at Sheerness. After the war he was with McLellan and Partners (then electrical consultants) as senior engineer until he joined The Steel Company of Wales in 1950 as deputy chief electrical engineer. In 1957 he became acting chief electrical engineer, and in 1960 he took up his present post. Mr Morgan is a member of the American Association of Iron and Steel Engineers, and he has been a member of The Iron and Steel Institute since 1953.

P. E. Peck, B.SC., A.M.I.E.E. – Engineer-in-charge, metal industries projects, plant applications engineering department, AEI Ltd (Heavy Plant Division), Rugby.

Philip Elworthy Peck attended Sedbergh School and University College, Nottingham, where he was awarded his B.SC. He served a three-year graduate apprenticeship with the British Thomson-Houston Co. Ltd, then joined the industrial engineering department of the company in 1937. After experience on a variety of application engineering work, including special wartime assignments, he joined the metal industries section of the department in 1944, and was placed in charge of the section in 1951. On the integration of the constituent firms of AEI he was appointed to his present post. He has been a member of The Iron and Steel Institute since 1953.

J. C. Wright, B.SC., PH.D. – Reader in industrial metallurgy, College of Advanced Technology, Birmingham.

John C. Wright was born in 1930 and educated at Dudley Grammar School. He obtained his B.SC.(HONS.) in metallurgy from the Birmingham College of Technology in 1954, and he was awarded his PH.D. in 1959, both being University of London degrees. While studying he worked in the Birmingham laboratories of what is now the International Nickel Company (Mond) Ltd, and in 1955 he joined the research department of ICI Metals Division. He was appointed senior research fellow at Wolverhampton and Staffordshire Technical College in 1956. In 1958 he joined the College of Advanced Technology, Birmingham, as senior lecturer in the metallurgy department, and in 1959 he was appointed to his present post as reader in industrial metallurgy. In May of this year he was elected to the Council of The Institution of Metallurgists.

J. C. Billington, B.SC., A.R.S.M., D.I.C., PH.D. – Senior lecturer, Department of Metallurgy, College of Advanced Technology, Birmingham.

Dr Billington was born in 1923 and attended Sir John Deane's Grammar School, Northwich, and the Royal School of Mines, from which he graduated in 1950. He then joined the Nuffield Research Group in Extraction Metallurgy, and afterwards the research department of Johnson, Matthey and Co. Ltd, Wembley. He was with the British Cast Iron Research Association from 1955 to 1959, when he took up his present post.

W. J. Elder, DIP. TECH., A.C.T.(BIRM.), L.I.M. – Metallurgist, Brush Electrical Engineering Co. Ltd, Loughborough.

William Johnstone Elder was born in 1937 and educated at Hamilton Academy and Loughborough Grammar School. He joined the central laboratories of the Brush group in 1955, and two years later, sponsored by Brush, he took the DIP. TECH. course at the College of Advanced Technology, Birmingham, during which he gained wide experience of basic metallurgical industries. He returned to Brush earlier this year and is now working on problems in engineering metallurgy.


J. C. Billington *W. J. Elder*

R. E. Kenderdine, B.SC., A.M.I.E.E. – Senior assistant electrical engineer, plant construction and central engineering department, Dorman Long (Steel) Ltd.

R. E. Kenderdine was educated at King Henry VIII Grammar School, Coventry, and at Birmingham University.

He joined The British Thomson-Houston Co. Ltd, Rugby, as a student apprentice, which he followed by a period on the company's outside erection staff. He then joined Merz and McLellan as an assistant electrical engineer, and later took a similar post with Dorman Long (Steel) Ltd, later being promoted to his present post.


J. C. Wright *J. C. Rowlands*

J. C. Rowlands – Experimental officer, Admiralty Central Dockyard Laboratory.

J. C. Rowlands was born in 1932 at Ellesmere, Shropshire, and attended King Edward VI Grammar School at Totnes. In 1951 he joined the Admiralty Materials Laboratory as an assistant experimental officer. He transferred to the Central Metallurgical Laboratory in 1955 and in the following year he joined the Central Dockyard Laboratory, where he continued his work on marine corrosion investigations. He was promoted to experimental officer in 1960.

NEWS OF SCIENCE AND INDUSTRY

Appointments

Tube Investments
Sir Ivan A. Stedeford has relinquished the managing directorship of Tube Investments Ltd but continues as executive chairman. Sir William Strath, Mr W. Hackett jun., and Mr R. D. Young have been appointed managing directors of the group.
Barrow Haematite Steel Company
Capt. G. E. Coles has resigned as chairman and from the board of Barrow Haematite Steel Co.
Firth Cleveland Tools Ltd
Mr W. H. Rigg has been appointed managing director of Firth Cleveland Tools Ltd.

NEL annual report

The National Engineering Laboratory of the DSIR has published its report for 1960. For about ten years the Laboratory has concentrated on cooperative work with industry, and the report outlines some of the main results of this activity. Work on automatic correction of errors in machine tools, on the development of hydrostatic power transmissions, and on the cold extrusion of steel, are three successful projects which could have significant application in UK industry. Basic and applied research have always been carried on hand in hand at the Laboratory; the report describes the scope and capacity of its facilities, and gives examples of sponsored work. The appendixes include a list of publications and patents. The *National Engineering Laboratory Annual Report 1960* is published for DSIR by HMSO, at 5*s*. (by post 5*s*. 5*d*.).

New continuous galvanizing line

John Summers and Sons Ltd have added a new continuous hot-dip galvanizing line to their works at Shotton near Chester. The fourth line at the works, it was designed by the company's chief engineer, Mr R. L. Willott and his staff, and the design has deliberately been kept simple to keep production hazards low and to ease external maintenance and control. Based essentially on the Sendzimir concept, the line can handle gauges of from 28 down to 14 and coil and strip up to 42in wide. Its maximum speed is 150 ft/min, and the maximum total connected electrical load is 1400 kW, although the plant will normally operate at 1000 kW. The main drives are voltage controlled by a motor generator and heating in the furnace is through automatically regulated transductor.

The line is completed by new corrugating and curving machines, made by Eichener Maschinenfabrik, which produce galvanized sheets of great accuracy.

John Summers are the largest UK producers of galvanized sheet, although nowadays only 15% of their output is corrugated. The new line is intended to enable them to achieve the qualities required in present conditions: uniformity and tightness of coat, good ductility, and the ability to stand up to forming.

Company news

'*Smiths make news*'
Thomas Smith and Sons (Rodley) Ltd are arranging for the distribution of a new film, '*Smiths make news*', which has been made on their behalf by Mottershaws of Sheffield. The company's main products are lifting and shifting machines, and the film uses the story of a newspaper reporter investigating a slum demolition scheme to illustrate the full range of the company's cranes and excavators in action under typical conditions. Industrial organizations who would like to see the film, or secretaries of groups, are asked to communicate with the Publicity Manager, Thomas Smith and Sons (Rodley) Ltd, Rodley, nr Leeds.

New plant and equipment

Ransomes and Rapier Ltd, of Ipswich, who are part of the Newton Chambers Group, have supplied a giant walking dragline, the Rapier W1800, which is to be used by the National Coal Board in the open-cast workings at Maeswyn Gap, Glyn Neath, South Wales. The largest machine of its type in Europe, the W1800 cost just over £900 000 and weighs 1 800 tons. The bucket weighs 33 tons with a maximum load capacity of 40 yd³. The basic length of the boom is 208 ft with the capacity of extension to 283 ft with a 30 ft³ bucket and 247 ft with a 40 ft³ bucket. The legs take strides of 7 ft 7in. There are eight 300-hp motors, four for hoist and four for drag, four 225-hp walk motors, and four 225-hp swing motors. On a crane gantry runs an overhead electric crane with two 10-ton grabs for maintenance purposes. The machine is driven electrically by Ward-Leonard Amplidyne control.

Polygram Casting Co. Ltd have announced a new automatic shell mould and coremaking machine, considered by its makers as being of revolutionary design. The machine is capable of producing cores from coreboxes of maximum size 28in × 18in × 12in at a rate of about 100/h. Further information may be obtained from Polygram Casting Co. Ltd, Shernfold Park, Frant, Tunbridge Wells, Kent.

Stewarts and Lloyds Ltd have opened a new coke-oven plant at Corby. Built by the Woodall-Duckham Company, the new plant will be known as the Deene Battery and will eventually form the nucleus of a new iron-making plant. The carbonizing capacity of the plant is 1 100 tons of coal per day, providing some 800 tons of metallurgical coke. A dry coke-oven gas-holder, manufactured by Ashmore, Benson and Pease has been installed, and also a desulphurizing plant, and a wet catalyst plant for the production of 23 tons/d of sulphuric acid.

Kover Järnverk Oy, which is owned jointly by the Swedish Kopparbergs group and the Finnish Vuoksenniska company, has started production on a new blast-furnace plant at Hangö in South Finland. Iron ore will be obtained from a deposit under the sea at Jussard; the furnace's annual capacity will be 250 000 tons, and it will supply OH pig iron to the Domnarfvet and Imatra steelworks.

CHANGES OF ADDRESS AND TITLE

Blackburn Aircraft Ltd and its two associate companies, Blackburn Engines Ltd and Blackburn Electronics Ltd, now use a new telephone number, Brough 67121.

Clyde Williams Corporation's European office is at John Adam House, 17–19 John Adam Street, London WC2.

Simmonds Aerocessories Ltd, a member of the Firth Cleveland group, has now moved its Birmingham Midland sales office to Herbert House, Cornwall Street, Birmingham. The telex and telephone numbers are: Telex 33–312, Birmingham Central 2248–9 and 2719.

'*The Australasian Engineer*' is now at 137–145 Walker Street, North Sydney, NSW, Australia.

The Australian Forge and Engineering Pty Ltd has changed its name to ANI Australian Forges Pty Ltd. Its address is unchanged, 14 Parramatta Road, Lidcombe, NSW, Australia.

DIARY

7 Dec. LIVERPOOL METALLURGICAL SOCIETY – Lecture, '*The explosive forming of metals*', by H. Thomas – Dept. of Metallurgy, University of Liverpool, Liverpool 3, 7 pm.

7 Dec. EBBW VALE METALLURGICAL SOCIETY – Lecture, '*Some advances in refractories for iron and steel furnaces*', by Dr J. H. Hyslop – RTB Welfare Hall, Ebbw Vale, 7.30 pm.

7–8 Dec. POWDER METALLURGY JOINT GROUP – Winter meeting – Church House, Great Smith Street, London SW1. (*See* November issue, p.309.)

13 Dec. NORTH WALES METALLURGICAL SOCIETY – Lecture, '*Radioisotopes in metallurgy. Some recent techniques and their applications*', by D. H. Houseman – Lecture theatre, Flintshire Technical College, Connah's Quay, nr Chester.

13 Dec. INSTITUTION OF ELECTRICAL ENGINEERS and BRITISH NUCLEAR ENERGY CONFERENCE – Lecture, '*Electrical aspects of Hunterston nuclear generating station*', by J. Henderson, K. J. Wootton, and G. F. Kennedy – Institution of Electrical Engineers, Savoy Place, London WC2.

13 Dec. SOCIETY FOR ANALYTICAL CHEMISTRY, MIDLANDS SECTION – Lecture, '*Fluorescent indicators for metals*', by Dr W. I. Stephen – University, Birmingham 15, 7 pm.

14 Dec. WEST OF SCOTLAND IRON AND STEEL INSTITUTE – Lecture, '*Operating experience with an 80-ton electric arc melting furnace*', by J. M. Mowat, A. G. McMillan, and R. McDonald – 39 Elmbank Crescent, Glasgow, 6.45 pm.

18 Dec. SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS – Lecture, '*Automatic billet inspection*', by M. H. Butterfield, A. Syke, and B. L. Davies – Engineering Lecture Theatre, St George's Square, Sheffield, 7.30 pm.

8–12 Jan. BRITISH NUCLEAR ENERGY SOCIETY and INSTITUTION OF MECHANICAL ENGINEERS – International conference on heat transfer – Lecture Hall, Central Hall, Westminster, London SW1.

10 Jan. NORTH WALES METALLURGICAL SOCIETY – Lecture, '*The electron metallography of steel*', by Prof. J. Nutting – Lecture Theatre, Flintshire Technical College, Connah's Quay, nr. Chester, 7 pm.

11 Jan. EAST MIDLANDS METALLURGICAL SOCIETY – Lecture, '*The new metals*', by Mrs M. K. McQuillan – Derby and District College of Art, Green Lane, Derby, 7.30 pm.

15–19 Jan. INSTITUTE OF PHYSICS AND PHYSICAL SOCIETY – 46th exhibition of scientific instruments and apparatus – Royal Horticultural Society, Vincent Square, London SW1.

17 Jan. INSTITUTE OF PHYSICS AND PHYSICAL SOCIETY, SOUTH WESTERN BRANCH – Lecture, '*Irradiation Effects in nuclear reactor materials*', by R. S. Barnes – College of Science and Technology, Bristol, 7 pm.

BRITISH IRON AND STEEL INDUSTRY TRANSLATION SERVICE

The following translations are now available, in addition to those given on page 314 of the November 1961 issue of the *Journal*. When ordering, please quote the number in bold type.

BISITS translations of papers presented at the International Steelworks Transport Conference – Milan, June 1961.

State of development of weighing installations in German steelworks. (From German.) D. PRÜSS. Mechanical and electrical types are reviewed with examples. (*JISI abstract.*) (£8 15*s*. 0*d*.) **[2101**

Technical weighing problems in the flow of materials in a steelworks. (From German.) LINTIG, H.-H. VON. (£3 5*s*. 0*d*.) **[2102**

The uneven flow of ore from ship to blast-furnace, influence of size of ship and of the handling rate at the stockyards at the coast and in the works. (From German.) DILLI, G. [This paper is substantially the first part of a longer paper by the same author, 'The Bunker on Wheels' – BISI 1587.] (£4) **[2103**

The weighing of wagons, lorries, and belt conveyors in the iron and steel industry. (From French.) BROCHU, M. (£7 10*s*. 0*d*.) **[2119**

Example of the study of a problem of internal transport by a simulation method. (From French.) LAFON, A. F. DE. (£3 10*s.* 0*d.*) [2120

Handling raw materials before they reach the blast-furnace; some aspects of transport and discharge. (From French.) BARBIER, M. (£3 15*s.* 0*d.*) [2129

Weighing in transport: technical and administrative aspects. (From Italian.) RICCI, A. (£2 15*s.* 0*d.*) [2147

The state of development of transport by lorries and other mobile equipment in German steelworks. (From German.) KOCH, W., and MÜLLER, A. (£5 10*s.* 0*d.*) [2177

The transport of raw materials to the blast-furnace. (From Italian.) CASSANI, R. (£3 10*s.*) [2269

Research on efficiency and cost of ore transport from a North Sea port to a Ruhr steelworks. (From German.) (£6 10*s.* 0*d.*) [2275

Systems of transport for supplying the blast-furnace. (From French.) MEVIS, M. (£3) [2345

(The price for each article is given in brackets; special price for complete set £40.)

The problem of clean air, with special reference to the iron and steel industry, particularly steelworks. IV. Keeping the air clean, an obligation and problem of our time (with discussion) (with bibliog., 64 refs.) (From German.) GUTHMANN, K., *Radex Rund.*, 1961, (1), Feb., pp.449–484. (£10) [1180, Pt.IV

The determination of the operating conditions of steelworks cranes and checking the basis for selecting their dimensions. (From German.) SVENSON, and SCHWEER, W., *Stahl Eisen*, 1960, *80*, Jan. 21, pp.79–90. (£7 5*s.* 0*d.*) [1621

Corrosion of steels in sea water. (From Russian.) BABAKOV, A. A. *et al.*, Spetsial'nye stali i splavy, sbornik trudov, vypusk 17. (Special steels and alloys, Collection of papers, issue No.17.) Tsentr. Nauchno-Issled. Inst. Chernoi met. (TsNIIChermet) – Inst. Kachestvennykh Stalei, pp.228–246. Moscow, Metallurgizdat, 1960. (£5 15*s.* 0*d.*) [2125

Metallurgy of the reduction processes taking place in the rotary kiln, development of a laboratory kiln. (From German.) WAHLSTER, M., *Tech. Mitt. Krupp.*, 1959, *17*, Dec., pp.330–342. (£6) [2158

Non-magnetic steels for high applied mechanical stresses. (From German.) KRONEIS, M., and GATTRINGER, R., *Stahl Eisen*, 1961, *81*, March 30, pp.431–445. (£7 15*s.* 0*d.*) [2182

A rapid test of the machinability of free cutting steels using the weight-feed method. (From German.) BECKER, H., *Stahl Eisen*, 1961, *81*, Jan. 5, pp.46–50. (£3 10*s.* 0*d.*) [2185

Determination of roll force and torque by experiment and calculation under the influence of strip tension (reel tension and drag tension). (From German.) MÜLLER, H. G., and FUNKE, P., *Stahl Eisen*, 1958, *78*, Oct. 30, pp.1564–1574. (£6 15*s.* 0*d.*) [2189

The effect on steel quality of the manner of introducing aluminium. (From Russian.) BRAININ, I. E., and GIBENKO, N. V., *Izvest VUZ Chernaya Met.*, 1959, Oct., pp.89–98. (£4 15*s.* 0*d.*) [2207

The influence of oxygen pressure on the oxidation rate of pure iron. (From German.) RAHMEL, A., and ENGELL, H. J., *Arch. Eisenhüt.*, 1959, *30*, Dec., pp.743–746. (£3) [2211

Comparing different methods for pneumatic ash removal. (From German.) NAGEL, R., and IBING, R., *Braunkohle Wärme und Energie*, 1960, *12*, Feb., pp.53–59. (£4) [2230

The effect of tri-axial pressure on the atomic magnetic moments of iron, nickel, and of the alloy Fe+36%Ni. (From Russian.) DEKHTYAR, I. YA., and MIKHALENKOV, B. S., *Izvest. VUZ-Fizika*, 1960, (6), pp.44–51. (£4) [2249

Evaluation of the results of electrical measurements on a geared blooming-slabbing mill with current converter feed and field reversal control. (From German.) NÜRNBERG, W. Part I, *Stahl Eisen*, 1961, *81*, April 27, pp.579–589. (£5 10*s.* 0*d.*) Part II, *ibid.*, pp.661–669. (£5 10*s.* 0*d.*) [2253

Desulphurization in the basic open-hearth furnace. (From Czech.) MOCEK, J., *Hutn. Listy*, 1959, *14*, (5), pp.405–409. (£3 15*s.* 0*d.*) [2255

Electromagnetic method for weld inspection. (From Russian.) KOLENDA, B. G. Chap. 3 (Part). The electromagnetic method: Chap.4 Construction of the electromagnetic detector MD–1380 Chap.5 Instructions for using the electromagnetic detector; Chap.6 Efficiency obtained from using the electromagnetic method. Leningrad, Sudpromgiz, 1959, pp.29–55. (£7) [2264

The forging down of heat-resisting steel ingots. (From Russian.) VALYAVKIN, F. M., *Kuznechno-Shtampov*, 1960, (7), pp.8–13 (£4 10*s.* 0*d.*) [2281

The temperature deformation rate factor in the plastic deformation of metals. (From Russian.) AGEEV, N. P., *Kuznechno-Shtampov.*, 1960, (7), pp.17–21. (£4) [2282

The modern technology of rolling heavy rails. (From Rumanian.) MICULESCU, R., *Met. Constr. Masini*, 1959, (11), pp.934–939; (12), pp.1033–1037. (£5 15*s.* 0*d.*) [2286

Separate ship-discharging and barge-loading in sea ports. (From German.) STRIKWERDA, S., *Stahl Eisen*, 1961, *81*, April 27, pp.529–537. (£6 5*s.* 0*d.*) [2294

The use of analogue or digital computers in solving heavy-current problems. III. Problems of the synchronous salient pole machine. (From German.) HANNAKAM, L., *De Ingenieur*, 1960, *72*, July 29, E.67–E.78; Aug. 12, E.79–E.94. (£10) [2298

Arsenic and phosphorus in high alloy Cr and Cr–Ni steels. (From Czech.) BENEŠ, F., and TLUSTA, D., *Hutn. Listy*, 1960, *15*, (12). pp.929–936. (£8 10*s.* 0*d.*) [2301

Inter-relation between the carbon content of steel sheets, the enamel and the firing temperature during the process of vitreous enamelling. (From German.) HORSTMANN, D., *Stahl Eisen*, 1961, *81*, May 11, pp.629–640. (£6 15*s.* 0*d.*) [2306

Manufacture and properties of atomized, stabilized, ferro-sillicon 45%Si. (From German.) FELDMANN, K., and FRANK, K., *Schweissen Schneiden*, 1960, *12*, Dec., pp.514–517. (£2 15*s.* 0*d.*) [2321

The effects of noise on workers in the iron and steel industry. (From German.) JANSEN, G., *Stahl Eisen*, 1961, *81*, Feb. 16, pp.217–220. (£2 15*s.* 0*d.*) [2323

Results of the use of automatic measuring and regulating equipment in open-hearth furnaces. (From German.) RABES, F., *Neue Hütte*, 1961, Feb., pp.65–71. (£5) [2324

Damage to tension wires by hydrogen absorption in aluminous cement concrete. (From German.) NAUMANN, F. K., and BAUMEL, A., *Arch. Eisenhüt.*, 1961, *32*, Feb., pp.89–94. (£4 15*s.* 0*d.*) [2325

Determination of the oxygen content of aluminium killed steels. (From German.) KOCH, W., and ABRESCH, K., *Stahl Eisen*, 1961, 81, June 8, pp.795–800. (£4 5*s.* 0*d.*) [2333

Influence of carbon content and experimental temperature on the work hardening and specific electrical resistance of ferritic and austenitic steels during cold deformation. (With discussion.) (From German.) SCHMIDTMANN, E. *et al.*, *Arch. Eisenhüt.*, 1960, *31*, May, pp.299–308. (£7) [2335

The degassing of light metal alloys by means of sonic vibrations. (From German.) ESMATCH, W. *et al.*, *Wissenschaftliche Veröffentlichungen aus den Siemens-Werken*, (Werkstoff Sonderheft), 1940, pp.78–87. (£3 10*s.* 0*d.*) [2336

Surface defects in precision casting. (From German.) NICKEL, E.-G., Paper given at the European Conference on Precision Casting, May 1958, Paris, pp.5. (£4 10*s.* 0*d.*) [2356

Control device for the electric current in steel melting arc furnaces. (From Russian.) SVENCHANSKII, A. D., *Vestnik Elektroprom.*, 1960, Aug., pp.23–26. (£3 5*s.* 0*d.*) [2365

Effect of method of plastic deformation on internal stresses in metal. (From Russian.) LYSAK, L. I., and SOGRISHIN, YU. P., *Sbornik nauch. rab. Inst. Metallofiz. Akad. Ukr.* (Kiev), 1959, (9), pp.22–26. (£2 10*s.* 0*d.*) [2371

The effect of the number of ingots on the aerodynamics and heat exchange in top fired soaking pits. (From Russian.) GLINKOV, M. A., and CHOI EN SIR, *Izvest. VUZ Chernaya Met.*, 1961, Jan., pp.184–190. (£4) [2376

Budgetary control and standard cost accounting in iron and steelworks. Experience in standard costing at Italian Steelworks, taking Cornigliano S.p.A. as an example. I. Introduction of a standard costing system as a tool for top management, GAVELLO, R. M. II. Comments on standard costing at Cornigliano S.p.A., RAUEN, J. (From German.) *Stahl Eisen*, 1961, *81*, July 28, pp.987–990. (£4) [2382

Flow in metals and power requirements of different extrusion techniques. (From German.) FISTER, W., *Techn. Mitt.*, 1961, *54*, Feb., pp.77–78. (£2 10*s.* 0*d.*) [2383

The iron ore deposits of the state of Minas Gerais (Brazil) and the Brazilian Iron and Steel Industry. (From German.) WEINER, K.-L., *Radex Rund.*, 1961, Aug., pp.623–640. (£8) [2389

The formation of Greek magnesite deposits. (From German.) PETRASCHECK, W. E., *Radex Rund.*, 1961, Aug., pp.641–646. (£3 10*s.* 0*d.*) [2390

Calculation of the power requirements for roller sheet straightening machines. (From German.) GELEJI, A., and DEVENYI, G., *Acta Technica*, 1957, (3–4), pp.361–380. (£4 5*s.* 0*d.*) [2393

A more accurate method of calculating [the torque and bending moment of sheet straightening machines for rolling mills. (From Russian.) KOROLEV, A. A., *Vestnik Mash.*, 1958, (10), pp.23–30. (£2 10*s.* 0*d.*) [2394

Contribution to the problem of a suitable drive for cold rolling reels. (From German.) BALTZ, W. E., *Stahl Eisen*, 1953, *73*, Oct. 22, pp.1404–1409. (£4) [2395

Typical features of the pre-cambrian quartz-banded ores of the Northern Labrador trough in Canada and their role in these formations. (From German.) TSCHOEPKE, R., *Techn. Mitt. Krupp*, 1961, *19*, (2), pp.73–77. (£3 5*s.* 0*d.*) [2396

Dynamic characteristics of open-hearth furnaces according to pressure in the melting chamber. (From Russian.) KOCHO, V. S. *et al.*, *Izvest. VUZ Chernaya Met.*, 1961, (6), pp.168–174. (£3 10*s.* 0*d.*) [2400

Excitation and control of large synchronous machines with current rectifiers. (From German.) HAAMANN, K. P., *Elektrotechnische Zeitschrift*, 1960, Ausgabe A, April 25, pp.317–323. (£4 15*s.* 0*d,*) [2403

Simulation of a synchronous machine with an analogue computer. (From German.) COROLLER, P., *De Ingenieur*, 1960, Sept. 16, E.103–E.109. (£3 5*s.* 0*d.*) [2406

Rod and tube drawing on modern drawbenches. (From German.) MAKELT, H., *Z. Metallk.*, 1961, *52*, Jan., pp.69–75. (£4 5*s.* 0*d.*) [2408

Equilibrium investigations on magnesiowüstites and magnesio-ferrites. (From German.) SCHMAHL, N. G. *et al.*, *Arch. Eisenhüt.*, 1961, *32*, May, pp.297–302. (£4) [2411

A contribution to the question of grain size behaviour in steel. (From German.) LEGAT, A. *et al.*, *Radex Rund.*, 1961, Aug., pp.657–663. (£3) [2415

Treatment of effluents in the manufacture and processing of wire and strip. (From German.) RÜB, F., *Draht*, 1961, *12*, (6), pp.263–269. (£5 5*s.* 0*d.*) [2421

Steel requirements of the under-developed countries. (From German.) SUENDORF, C., *Stahl Eisen*, 1961, *81*, Aug. 3, pp.1093–1094. (£2) [2425

A guide to scientific and technical reference works. Metal science and metallurgical processes section. (From Chinese.) (Translated from a microfilm obtained from America.) ZHAO HI-SHENG (Compiler). (£4) (To libraries of academic institutions £1.) [2449

Heat-resistant steel as a bolting material for steam power installations. (From Russian.) LIBERMAN, L. YA., and SOKOLOVA, M. N., *Teoplenergietka*, 1961, *8*, May, pp.28–34. (£3 5*s.* 0*d.*) [2451

Designing passes and tools for manufacturing bolts on automatic lines. (From Russian.) GLADKIKH, A. N., and MASLENNIKOV, N. I., *Kuznechno-Shtampov.*, 1960, (10), pp.21–24. (£3) [2454

The effect of sinter handling on the change of its grain composition. (From Russian.) RUDAKOV, L. M., and GORSHTEIN, I. I., *Metallurg*, 1961, *6*, April, pp.4–6. (£1 15*s.* 0*d.*) [2457

ABSTRACTS OF CURRENT LITERATURE AND BOOK NOTICES *Iron and Steel Manufacture and Related Subjects*

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ABSTRACTS

These abstracts are also available on index cards in advance of publication in the *Journal*, each abstract being classified under the Universal Decimal system (UDC). Details and subscription notes can be obtained from the Secretary, The Iron and Steel Institute.

MINERAL RESOURCES

Molybdenum supply for the French iron and steel industry (*Aciers Fins. Spéc.*, 1960, Dec., 4–21).

The occurrence of magnesite in Central Ceará (Brazil) H. Grabert (*Berg. Hütten. Monatsh.*, 1960, Oct., **105**, 221–225).

ORES, MINING AND TREATMENT

Summary of methods of working the Lorraine iron ore mines Tincelin (*Rev. Ind. Min.*, 1960, Dec. 15, Special Number, 99–107) [In French].

The Soumont iron ore mines H. Quinquet (*Rev. Ind. Min.*, 1960, Dec. 15, Special Number, 83–98) [In French] A detailed survey of iron ore mines worked by Societé des Mines de Soumont. Annual production has increased from 100 000 t in 1927 to 900 000 t in 1939 and over 10^6 t at present.

Contribution to the study of iron ore from May-sur-Orne (Calvados) G. Gourty (**Bull. Soc. Géol. France*, 1959, 7th series, **1**, (5), 500–510) The main deposits from May-sur-Orne are described in stratigraphical order, and an attempt is made to interpret them.

Manganese at Gabon P. L. Douffiagues (*Mines Met.*, 1960, Nov., 642–644).

Methods of subterranean working of Marquesado hematite deposits G. Roziere (*Rev. Ind. Min.*, 1960, Dec. 15, Special Number, 65–75) [In French] This article describes the open and underground mining of a large deposit of hematite in the Sierra Nevada in Grenada in Spain. The ore is 54%Fe and reserves are estimated at 16×10^6 t above the hydrostatic level, of which one-third must be mined underground. There are also 10^7 t below the hydrostatic level.

Mineral raw materials for the two-million-ton project B. N. Engineer (*Iron Steel Rev.*, 1960, Tata No., 103–106).

Glossary of metal mining terms (*Rev. Ind. Min.*, 1960, Dec. 15, Special Number, 5–20) [In French].

Pilot plants in metallurgical research at Fried. Krupp, Essen H. Krainer (*NML Pilot Plant Symp.*, 1960, July, 131–136) Examples of pilot plants operated by Krupp's Research Centre for experimental work on iron ore reduction outside the blast-furnace and on oxygen steel using the LD process are presented and their operations briefly described with results of tests.—S.H.-S.

Crushing and blending in iron mines J. Maret (*Arts et Manuf.*, 1960, (104), Dec., 54–56).

Iron ore beneficiation A. Temoin and M. Pasquet (*Arts et Manuf.*, 1960, (104), 57–61).

The optimum degree of concentration of iron ore Z. A. Kulagina (*Stal'*, 1961, (6), 486–489) Studies of Krivoi-Rog, Kachkanar, and Nizhe-Angar ore beneficiation processes are combined to find the most economic process and degree of treatment.

Topical problems of dolomite plants J. Frontczak (*Hutnik*, 1961, **28**, (4), 163–165) Dolomite used by the Polish steelplants (40 kg/t of steel) contains too much minus 4 mm fraction which has to be rejected. As the chemical composition is within the specification (MgO: minimum 28%, iron oxide: max. 7%SiO_2: max. 5%) the main source of unsintered dolomite is ascribed by the author to the coke, which often falls short in grading, abrasion resistance, and calorific value. Yet the lack of properly trained staff and even of laboratories to test the coke as well as its shortage make the dolomite plants use any coke available. Apart from bad coke, wrong grading of the raw dolomite together with its wrong distribution in the furnace often results in channelling, which in its turn gives rise to unsintered dolomite.

Flotation of unoxidized manganiferous material from the Cuyuna Range, Minn. F. W. Wessel, P. A. Wasson, and D. W. Frommer (*US Bur. Mines Rep. Invest.* 5802, 1961, pp.14)

Pilot plants for the agglomeration of iron ores on a semi-industrial scale H. Rausch and F. Cappel (*NML Pilot Plant Symp.*, 1960, July, 143–152) Semi-industrial testing equipment for the performance of investigations on both sintering and pelletizing processes are described and data on their operation and results are presented and discussed.—S.H.-S.

Pelletizing by the grate-kiln method at Humboldt J. S. Westwater (*Blast Furn, Steel Plant*, 1961, **49**, June, 513–518) Description of the plant at Humboldt where concentrates from low-grade hematite ore are mixed with bentonite and pelletized prior to further treatment.—A.W.D.H.

On the kinetics of iron and steel reactions. Part I. Sintering, outgassing, reducing L. von Bogdandy (*Arch. Eisenh.*, 1961, **32**, May, 275–286) [In German] Aspects dealt with include the importance of the speed of materials transport, the reaction of solid charge with gases, reaction of hot metal with gases, the importance of the combination of transport processes and reaction stages in speeding up operations, reduction of iron oxides by gases in stationary charges and in agitated layers. Effect on ore reduction in the blast-furnace and a new process of ore reduction using gases. **Part II. Evaporation and refining** Aspects dealt with include theory of nucleation, drop nucleation in the formation of brown fume in the oxygen steel process, theory of the decarburization of pig iron, application of the theory to decarburization in the OH furnace and in the oxygen process.

Iron ore sintering A. Jacquin and A. Roederer (*Arts et Manuf.*, 1960, (104), Dec., 62–65).

The role of the pilot plant in iron ore sintering A. Grieve and F. Ely (*NML Pilot Plant Symp.*, 1960, July, 153–159) The operation of a moving pellet strand type pilot sintering plant at Simon Carves research department at Cheadle Heath is described and data on results are presented.—S.H.-S.

The automation of the sintering process V. S. Abramov and A. G. Mikhalevich (*Stal'*, 1961, (6), 481–486) For continuous production continuous control is needed. A magnetic method is described which records FeO continuously (in the form of Fe_3O_4). Trials are described and the new permeameter was found satisfactory. Construction and operation are given in detail. Further developments should control fuel supply and also strand speed.

The present and future role of sintering in iron making. A lecture E. W. Voice (*NML Pilot Plant Symp.*, 1960, July, 287–295) After briefly reviewing blast-furnace operation, a general description of sintering is presented and discussed, covering heat-flow techniques, pilot-scale experiments using iron ores, experimental results, specific air and waste-gas volumes, fuel requirements for sintering, heat-flow experiments without combustion, sintering with various fuels and atmospheres, igni-

tion and the influence of preheated air, concluding with a brief summary.—S.H.-S.

The use of an electronic metal-detector at a sinter plant D. P. Pritykin (*Stal'*, 1961, (6), 490–492) Removal of metal from limestone and other materials on the way to the crushers protects the hammer mill from damage. The circuit is shown and the device is used beyond the electromagnet for tramp metal removal. An automatic device to clear a section of the conveyor belt on the detection of metal should be developed.

Equilibrium tests on magnesium–wüstite and magnesium–ferrite N. G. Schmahl, B. Frisch, and G. Stock (*Arch. Eisenh.*, 1961, **32**, May, 297–302) [In German] New equilibrium measurements of the system $FeO-O_2-MgO-CO-CO_2$ at 800, 900, and 1 000°C are given. Theoretical treatments of the system in relation to iron oxide–magnesium oxide activity and the fields of existence of magnesium–wüstite and magnesium–ferrite are presented.

The reactions of manganese-bearing iron with its oxides in lime crucibles W. A. Fischer and H. J. Fleischer (*Arch. Eisenh.*, 1961, **32**, May, 305–313) [In German] Aspects dealt with include the contents of smelted iron and slag in the lime crucible, the iron oxide, MnO, lime, and the peripheral systems, the deoxidation of melted iron using Mn with lime and saturated oxidized slags and the deoxidation of iron using Mn and solid lime.

Natural gas in reduction reactions of iron ores in a fluidized layer K. P. Lavrovskii, A. L. Rozental', and A. Kh. Eglit (*Izvest. AN Otdel. Tekhn. Met. i Toplivo*, 1961, (2), 13–19) It is shown that it is possible, in principle, to achieve the direct reduction of iron ores with natural gas in a fluidized layer. Methods were examined for supplying heat for the process. By heating the layer with the heat of combustion of flue gases, the CH_4 consumption for the reduction of 1 kg iron did not exceed 0·5 m³ at NTP (14 refs).—A.I.P.

Reducibility of Salem magnetite ore M. Subramaniam and P. P. Bhatnagar (*J. Sci. Indust. Res.*, 1960, **19A**, Dec., 620–624) The concentrate obtained by wet magnetic concentration was stated to be suitable for pig iron production in conventional blast-furnaces after agglomeration. The Si-content was 13·4% but the reducibility was comparable to ores with 5·0–7·0%Si and the only drawback was the high slag volumes.—C.V.

The effect of mixed firing on the Dwight-Lloyd process J. Tuboly (*Koh. Lapok*, 1961, **94**, May, 205–210) Mixed firing with coke breeze and top gas or liquid fuel decreases the heat consumption of the Dwight-Lloyd ore-sintering process, and increases the strength and reducibility of the product.—P.K.

FUEL—PREPARATION, PROPERTIES AND USES

Coal for two million tons of steel B. H. Engineer (*Iron Steel Rev.*, 1960, *Tata No.*, 93–95) A short review of sources of supply of extra coal needed to meet the Tata Steel Co.'s increased demand arising from their doubled steel output.—S.H.-S.

Electro-hydraulic crushing of coal B. I. Losev, A. N. Mel'nikova, F. Ya. Saprykin, and L. A. Yutkin (*Vestnik Akad Nauk*, 1959, **6**, 62–65).

A contribution to the evaluation of the performance of an improved 'Karol' type hammer mill F. Szwejda (**Koks-Smola-Gaz* (Poland), 1958, **3**, (1), 25–27).

Coal blending and coking research M. R. Dinker (*Iron Steel Rev.*, 1960, *Tata No.*, 177–179).

Carbonizing tests with Tuscaloosa oven: studies of pushing pressures J. B. Gayle and W. H. Eddy (*US Bur. Mines Rep. Invest.* 5807, 1961, pp.14) Report on an investigation into the factors affecting pushing pressure in a small electrically heated coke-oven. A mechanism is proposed to explain the occurrence of stickers and hard pushing ovens.—A.W.D.H.

Pilot plant studies on the production of metallurgical coke N. N. Das Gupta, S. Banerjee, N. N. Chatterjee, and M. V. P. Menon (*NML Pilot Plant Symp.*, 1960, July, 213–216) A brief description of some US, French, British, Japanese, German, and Indian pilot ovens, and their operation and results, is presented and Indian data are tabulated.—S.H.-S.

AIR POLLUTION AND SMOKE

Electro-precipitator for 'Ajax' D. O. Heinrich (*Iron Steel*, 1960, **33**, Sept., 452–457).

Gas collection in open electric furnaces M. Seur (*Radex Rund.*, 1961, June, 607–615) [In German] The bulk of the gas from open electric furnaces can be concentrated and collected by surrounding each electrode with a water-cooled, bell-shaped hood; the gas yield of commercial furnaces up to now is 70–95% and there is better dust separation.

TEMPERATURE MEASUREMENT AND CONTROL

Bibliography of temperature measurement January 1953 to June 1960 C. Halpern and R. J. Moffat (*NBS Monograph*, 1961, **27**, April, pp.13).

Corrected optical pyrometer readings D. E. Poland, J. W. Green, and J. L. Margrave (*NBS Monographs*, 1961, (30), April, pp.74) A table of true temp., against optical pyrometer readings between 1000°K and 39 900°K, for 49 emissivity values between 0·02 and 0·98.

REFRACTORY MATERIALS

Refractory materials for the iron and steel industry. Part IV J. M. Palacios Repáraz (*Dyna.*, 1960, **35**, Dec., 929–941).

Development of metallurgical refractories with Indian raw materials: pilot plant studies T. V. Prasall and H. V. Bhaskar Rao (*NML Pilot Plant Symp.*, 1960, July, 197–203) A brief account of various research projects pursued in the NPL Laboratory towards the development of refractories from indigenous raw materials is presented, followed by a description of the scope of a resultant pilot plant now in course of installation.—S.H.-S.

Raising refractory capacity for the two-million-ton project H. K. Mitra (*Iron Steel Rev.*, 1960, *Tata No.*, 131–134) The requirements of additional refractory supply to meet the increased Tata steelworks' capacity is discussed and Belpahar Refractories Co., a joint concern of the Tata Iron & Steel Co., and Didier-Werke of Germany is briefly described.

Tests of the characteristics of Halden dolomite F. Bischoff (*Arch. Eisenh.*, 1961, **32**, May, 345–352) [In German].

Burnt lime as a refractory for LD converters F. Nadachowski (*Hutnik*, 1961, **28**, (4), 143–147) It is not Fe_2O_3 but the silicates from the Si in the blown metal that destroy the dolomite, and the presence of MgO not only does not prevent the destruction but on the contrary it promotes it since both MgO, CaO silicates, monticellite, and mervinite are not refractory while $2CaO, SiO_2$ is. Since hydration occurs in dolomite also, and could be prevented by tarring, what matters is the effect of tarring on refractoriness. Now while MgO is reduced to volatile Mg metal which evaporates, making thus dolomite porous and friable, CaO is reduced to CaC_2 which is only slightly less refractory than CaO, and therefore burnt lime should be a better refractory than dolomite as refractory lining. As for the Fe oxides, their formation is restricted to the neighbourhood of the oxygen land, the lining itself being continuously swept by CO that precludes the formation of any Fe oxides.

Studies on raw materials for casting-pit refractories. Studies on super-duty casting-pit refractories for steel plant. 1. S. Nagai, G. Yamaguchi, Z. Ota, F. Tanemura, and M. Tsukino (*Ann. Rep. Eng. Res. Inst. Univ. Tokyo*, 1960, **19**, Sept., 115–118) The raw materials used for the examination were Iwate B clay, Iwate clay shale, washed Gifu Gairome clay, Nagano and Yajuna Rosekis (agalmatilites), respectively.—C.F.C.

A study of the slagging process in refractory bricks K. Konopicky and G. Routschka (**Deutsche Keram. Ges. e.V.*, 1961, Jan., 1–8) A report discusses the theoretical basis for the migration of liquid phases during the slagging of refractory products, and the influence of absorptive processes similar to those in chromatography.

IRON AND STEEL—GENERAL

Metallurgy since the beginning of the century A. Gronningsaeter (*Can. Min. J.*, 1960, **81**, Dec., 76–82).

Symposium on pilot plants. Scope of pilot plant research and development at the National Metallurgical Laboratory B. R. Nijhawan (*NML Pilot Plant Symp.*, 1960, July, 36–49) A review is presented covering: (1) pilot plants at present in operation at the laboratory; (2) others in process of establishment during the Second Five Year Plan period; and (3) those projected for the Third Five Year Plan period. An overall survey of the role of pilot plants especially those operating on Indian manganese ores and cognate developments includes a table of properties of some of the refractories produced at the NML and a brief review of projected development for the Third period, followed by a short discussion. **Some aspects of pilot plant research and development in iron and steel industry** (106–112) Pilot plant scale investigations are surveyed in reference to sinter, ironmaking, steelmaking, and basic air side-blown converter steelmaking, in a series of Russian and other overseas plants, with a brief discussion.—S.H.-S.

The relationship of pilot plants to full scale operation B. Swarup and G. R. Bashforth (*NML Pilot Plant Symp.*, 1960, July, 74–82).

Role of metallurgical pilot plants in the United States H. G. Iverson (*NML Pilot Plant Symp.*, 1960, July, 83–90) A survey is presented of prerequisite data, types and sizes of pilot plants, primary and other benefits derived therefrom, and metallurgical pilot plant research at the US Bureau of Mines, supported by a table of some Bureau of Mines plants, with approximate capacities and results, a selected bibliography of 32 items, pertaining to alumina, iron, manganese, mica, titanium, zirconium, and general matters, the whole followed by a discussion on the subjects presented.—S.H.-S.

The French iron and steel industry P. Epron (*Arts et Manuf.*, 1960, (104), Dec., 48–49).

New developments in Soviet metallurgy N. Zakharov (*Iron Steel Rev.*, 1960, **4**, Nov., 25–26) Large electric furnaces for steelmaking, automatic moulding machines, a midget rolling mill, and a blast-furnace weighing car are mentioned.—C.V.

The steel industry in India G. Grenier (*Mines Met.*, 1960, Nov., 637–639).

The place of T.I.S.C.O. in India's steel history J. J. Ghandy (*Iron Steel Rev.*, 1960, *Tata No.*, 41–49).

Planning for T.M.P. N. Sen (*Iron Steel Rev.*, 1960, *Tata No.*, 85–91) A full-length account of the detailed planning and surveys proposed for the 2 m. ton programme involved in doubling the capacity of the Tata Steel works with data on agreements with the Kaiser Engineers Co. of California.—S.H.-S.

Prospects of iron and steel development in India P. S. Lokanathan (*Iron Steel Rev.*, 1960, *Tata No.*, 53–56) The decision of the Indian Government to set up a fourth steel plant at Bokaro is supported on the economic grounds that it is advisable to keep basic steel capacity a step ahead of consumption, with an analysis of the demand pattern of the country, a suggestion that the fourth plant should concentrate on flat products, supported by a view that price policy needs careful Government re-examination and that distribution and production should be coordinated and centralized by the establishment of a body similar to the Iron and Steel Board of the United Kingdom.—S.H.-S.

Manufacture of alloy, tool steels and tungsten carbide in India P. H. Kutar (*Iron Steel Rev.*, 1960, *Tata No.*, 63–67) The need to develop adequate capacity for the manufacture of alloy and tool steels in order to keep pace with the production of iron and steel is discussed.

The steel industry of Japan (*Japan Iron & Steel Federation*, 1960, pp.32).

BLAST-FURNACE PRACTICE AND PRODUCTION OF PIG IRON

New plant for hematite pig iron (*Engineer*, 1961, **211**, May, 776–777) A description of new

blast-furnace, and ancillary equipment at Millom, Cumberland.—A.W.D.H.

Modern design features in the new Millom blast furnace (*Iron Coal Trades Rev.*, 1961, **182,** May, 1015–1017).

The new blast furnace for the T.M.P. P. K. Chatterjee (*Iron Steel Rev.*, 1960, *Tata No.*, 145–155) The new and sixth blast-furnace erected by the Tata as the key unit in their new programme—the biggest unit in Asia—its erection, equipment, operation, and control, are described.—S.H.-S.

The smelting of titaniferous iron ores B. A. Hincks (*Broken Hill Res. Div. Inf. Circ. No.*7, 1960, Feb. 8, pp.35) A review of smelting trials with titaniferous ores in various countries is followed by a statement of objections to their use such as high fuel consumption, hearth accretion and slag viscosity, and a survey of conditions requisite for successful smelting, comprising fluid slag with low lime–silica ratio, alumina slags, alkaline slags, and furnace operation (at Jones and Laughlin). The reduction of silicon and the influence of temperature upon it are discussed, and the use of electric smelting as compared with blast-furnace smelting is briefly mentioned.—S.H.-S.

The uses and limitations of pilot plants in studying iron making problems E. W. Voice (*NML Pilot Plant Symp.*, 1960, July, 50–52) A brief review.—S.H.-S.

The study of a small blast furnace profile Wong Tse-kong and Hsian Chung-yung (*Iron and Steel*, 1959, (2), 33–44; from *Sci. Abs. China, Techn. Sci.*, 1959, (2), 74) A profile is derived from study of a <200 m^3 furnace.

Analysis and calculation of blast furnace performance L. Bousmanne (*Rev. Univ. Mines*, 1961, **104,** June, 336–364) [In French] An examination is first made of operational data of a large number of blast-furnaces. The examination of heat losses at the top leads to a study of heat exchangers for which the author puts forward an original theory which leads to the idea of a temp. of inversion in the blast furnace. The resulting calculation is given in detail. The author shows using various examples how the ideas developed enable most of the problems which arise in blast-furnace operation to be solved.

The application of refractory concrete in the blast furnace Chang Yun-chuan and Fan Shu-ying (*Metallurgical Construction*, 1959, (4), 12–14; from *Sci. Abs. China Techn. Sci.*, 1959 (2), 73).

Ore-dressing and the lime/silica ratio W. Wozniacki, J. Wanot, and S. Zeilinski (*Hutnik*, 1961, **28,** (4), 155–162) Blast-furnaces in a certain Polish steel plant rely chiefly on calcined siderite and Krivoi Rog lump ore, and though the stock of the former is kept sufficiently large for effective ore-dressing yet, because of an irregular supply the latter has sometimes to be charged as supplied, in consequence of which the ratio varied from 0·9 to 1·4.

Problems of blast furnace operation with 2000°F blast temperature R. T. Hanna (*Blast Furn. Steel Plant*, 1961, **49,** June, 525–528) Hot blast temp. up to 2000°F necessitate certain changes in blast-furnace ancillary equipment. These include the lining of all exposed metal with refractory material, the use, where possible, of oxidation-resistant alloys, and improvements in water cooling. Small changes were also necessary in the heating stove cycle.—A.W.D.H.

Future developments in blast-furnace practice N. S. Krasavtsev (*Hutník*, 1961, **11,** (4), 158–161) [In Czech].

The performance of a rammed carbon lining in a small blast furnace (*Metallurgical Construction*, 1959, (5), 14–18; from *Sci. Abs. China, Techn. Sci.*, 1959, (2), 75) The lining of the 13 m^3 furnace was inspected after blow down and regions of erosion located. Recommendations for lining with carbon are made.

Recent progress in the operation of the blast furnace. Changes under investigation G. Aubert (*Arts et Manuf.*, 1960, (104), Dec., 66–68).

Experiments on blast furnace operation in Yawata Iron and Steel Works K. Wada and A. Honda (*NML Pilot Plant Symp.*, 1960, July, 169–181).

Blast furnace fuel injection D. Penny (*Broken Hill Res. Div. Inf. Circ. No.*12, 1961, March, pp.51) After a brief introductory discussion of the purposes and effects of injection the subject is presented under three main headings, theoretical considerations, operational experience, and the mechanics of fuel injection, with suitable sub-headings in each case. Operational experience is reviewed by countries, relation to their available fuels, with tabulated data covering plant, fuel injected, fuel rate, site of injection, blast temperatures before and during injection, oxygen enrichment of blast, and coke rate decrease.

Investigation of the blast-furnace process with the introduction of liquid fuel into the hearth Yu. S. Borisov and A. A. Fofanov (*Stal'*, 1961, (6), 492–498) Numerous trials are described with the conclusions that oil at the rate of 87–95 kg/t pig iron introduced into the tuyeres reduces coke rate (14·2–15·7%) and increases productivity 4·1–8·8% with increase of blast temp. (37–50°) and decreased humidity (4–5 g H_2O/m^3) with savings in fuel cost. Studies using O_2 are recommended.

Rational utilization of calcined Bakal' siderites in the blast-furnace charge B. A. Savel'ev and A. G. Zhunev (*Stal'*, 1961, (6), 498) A note from Chelyabinsk. Laboratory tests on a furnace with a capacity of 600 t/day gave optimum roasting conditions. Use of 50–60% of this instead of limonites gave 13·5% increase of productivity, coke 10·3% less, and limestone 58% less.

Kinetics of the desulphurization of pig iron by slags I. S. Kulikov (*Izvest. AN Otdel, Techn. Met. i Toplivo*, 1961, (2), 20–30) It is shown that transfer of the sulphur from the metal into the slag takes place in the form of FeS accompanied by Fe. This confirms the classical mechanism of the desulphurization of pig iron by slags in the presence of carbon. Many details of the kinetics of the desulphurization process were established (19 refs).

Salt water and steelmaking (*BHP Rev.*, 1960, **38,** Dec., 24–26).

Automatic control of blast furnaces S. Balogh (*Koh. Lapok*, 1961, **94,** March, 129–134).

Experience with the continuous control room monitoring of the basic production processes E. Z. Freidenzon (*Stal'*, 1961, (5), 458–460) An account of the NTMK automatic remote control system working on a blast-furnace/OH system and rolling mill. The monitoring system for the OH furnaces requires further development.

American steelworks plant for blast-furnace air supply (*Oil Eng. and Gas Tur.*, 1960, **28,** Mid-Nov., (No.325), 272–274) A Westinghouse type W–201 RE gas turbine blower set, for the supply of air to blast-furnaces engaged in the production of steel at the US Steel Corp.'s South Chicago Works, is described with technical and operating detail.—S.H.-S.

Hot blast pebble stove practice Hu Tin-shian and Liu Ming-cheng (*Iron and Steel*, 1959, (1), 19–22; from *Sci. Abs. China, Techn. Sci.*, 1959, (2), 74) High-alumina fireclay balls are used in two blast-furnace stoves.

Recent aspects of the hot-blast stove combustion control at Hirohata Works K. Kusuno, K. Nakayama, and K. Esaki (*Suiyokway-Shi*, 1959, **14,** Dec., 31–34) At Hirohata Works, coke-ratio has been decreased by pre-treatment of ores and the use of constant-humidity blast. This improvement could be increased by high temp. blowing. In order to operate the blast-furnace on steady high-temp. blast, the authors have prepared an operation standard for hot-blast stove combustion and have estimated the value of this standard.

The low-carbonisation and smelting process in the low-shaft furnace H. Reinfeld (*NML Pilot Plant Symp.*, 1960, July, 266–270) A paper is presented based on the operational results of the low shaft furnace plant at Troisdorf (near Cologne) in Western Germany, above a fully-automatic charging system which allows any charging cycle, so that by adaptation to the furnace operation and the charged material, the charging sequences can be made variable to any length of period. A table with analyses of pig iron, top gas, coal, coke, and briquette mixture is appended, and results of other small furnaces are also included.—S.H.-S.

SLAGS—PROPERTIES, TREATMENT AND USES

Prince and beggar (Manufacture of slag into cement) (**Ekonomicheskaya Gazeta*, 1960 June 18, pp.2).

Slag: value from waste (*BHP Rev.*, 1960, **38,** Dec., 16–18).

Thermal content of mixtures in the system ferrous oxide–zinc oxide–silica Z. F. Gulyanitskaya, R. N. Petrova, and D. M. Chizhikov (*Izvest. AN Otdel, Tekhn. Met. i.Toplivo*, 1961, (2), 55–59) The thermal content of slags of the system FeO–ZnO–SiO_2 varies depending on composition from 208·0 to 290·0 cal/g at 1200° and from 217·0 to 306·0 cal/g at 1300°. The greatest thermal-content values at 1200° and 1300° are for slags in which the SiO_2/FeO content is constant.—A.I.P.

DIRECT PROCESSES

Direct reduction of iron ore C. C. McAneny (*Eng. Min. J.*, 1960, **161,** Dec., 83–99) Many well-known processes are summarized and compared.

Processes for the direct reduction of iron ores B. A. Hincks (*Broken Hill Res. Div. Inf. Circ. No.*10, 1960, June, pp.149) After a brief review of the reasons for interest in direct reduction of iron ores, with reference to various countries, a comprehensive survey is presented in which direct reduction processes are described in seven groups: (A) rotary furnace processes (17). (B) Fluidized bed processes (10). (C) Shaft furnace processes (8). (D) Electric furnace processes (4). (E) Batch retort processes (5). (F) Travelling grate processes (2). (G) Tunnel kiln process (1).

Direct reduction processes J. Jackson (*Iron Steel*, 1961, **34,** May, 192–193) Tests of the Swedish Höganäs process carried out on two Brazilian fine hematite ores (Itabira and Andrade) with two types of Brazilian coal and with eucalyptus wood charcoal, with a view to by-passing blast-furnaces in the production of iron, are described; and other processes with a similar object, especially a fluidized-bed method with a gaseous reducing agent in New Zealand, and others in plants in France, Germany, and Czechoslovakia, are briefly presented.—S.H.-S.

The present status of direct reduction processes for iron ore J. Astier (*Arts et Manuf.*, 1960, (104), Dec., 75–77).

PRODUCTION OF STEEL

The new steel melting shop furnaces fired with liquid fuels and coke oven gas J. Sanjana (*Iron Steel Rev.*, 1960, *Tata No.*, 119–124).

Steel melting in a pilot plant shaft furnace J. W. Eyre, C. Hulse, and M. W. Thring (*NML Pilot Plant Symp.*, 1960, July, 119–130) Trials carried out in a gas-fired furnace and results are described.

Investigation of the autocarburetting of injected petroleum gas in an open hearth furnace port M. A. Magidson (*Stal'*, 1961, (6), 566) A note from Chelyabinsk and Magnitogorsk. Gas is injected at the doghouse and air along the former gas line at a rate of 10% of the total thermal load. A hydraulic model of the port was studied and recommendations were made.

Variation of oxide inclusion count during the various stages of open hearth steel making S. L. Levin and I. P. Kazachkov (*Nauchn. Doklady Vyssj. Shkoly-Metallurgiya*, 1959, (2), 43–47) OH heats of C steel using the scrap process were investigated; the amount and composition of oxide inclusions while the steel is held in the furnace, the effect of rate of C removal before deoxidation; oxide inclusions during deoxidizing with FeMn+FeSi and with FeMn alone; and oxide inclusions in the steel during deoxidation in the ladle, during pouring and when adding Al to the pouring steel were investigated.

Comprehensive automation of the thermal operating conditions of open hearth furnaces Yu. N. Tuluevskii (*Stal'*, 1961, (6), 566) A note from Chelyabinsk, and the A. K. Serov combine. The system is controlled by a measurement of excess air and by pressure in the working space. Productivity increased and fuel consumption decreased, each by 5%.

Smelting low-alloy steels in 500 ton open-hearth furnaces E. V. Abrosimov, V. A. Shcherbakov, M. P. Sabiev, and E. P. Dryapik (*Stal'*, 1961, (6), 499–504) Quality is equal to that from 250-t furnaces but if the sulphur content of the charge is high, the output of the large furnaces is relatively lower. Operation is described and the effects of C, S, and P are considered. Outputs are respectively 38·2 and 26·7, yield is t/m²/h 8·95 and 8·13 and fuel consumption 134 and 147 kg/t.

Hot patching basic open hearths Harbison-Walker Refractories Co. (*Refract. J.*, 1960, **36**, Sept., 278) A new slurry-mix, mixer, and gun combination is discussed which allows of gradual and even application of suitable material in open-hearth furnaces. The mix is a fine-ground refractory material in either Cr-base or Cr-magnesite-base; both give fast-setting bonds which are capable of developing high strength. The mix, and mixer, are described. The latter has a steam jacket attachment which activates the plasticizers and ensures max. adherence. The pressure vessel-type gun holds 1 500 lb slurry and, connected to 80 lb air pressure spraying is done with a 1in dia. pipe attached to the hose. Two men, one controlling the valve and the other the nozzle can apply the entire 1 500 lb in 10 min.

Investigation of the running of open hearth furnaces fired with natural gas S. Ya. Skoblo (*Stal'*, 1961, (5), 414) A note from Zhdanov. Gas at 9 atm can be used to atomize tar.

Development of an open hearth furnace of a new shape E. Boelens (*Silicates Ind.*, 1961, **26**, March, 131–140) [In French] Since 1955 the new shape OH furnaces of the Frivegnee works of Cockerill-Ougree have been modified and refractory life substantially increased thereby. The 35 t basic-lined furnaces have a life of more than 800 heats without repairs.

An effective layout for regenerator checkers G. I. Antonov and Sh. M. Berman (*Stal'*, 1961, (5), 413–414) This refers to a previous article by Lomakin, Piskarev, and Rybnikov (*ibid.*, 1960, (8)) where the need for better refractories was stressed, but here the removal of the dust is claimed as equally effective. Laid as described, forsterite brick partly unfired, can be used, replacing more expensive types and avoiding the top courses of silica brick.

Analog computers to facilitate research in steelmaking processes [at Jones and Laughlin] (*Indust. Heat.*, 1960, **27**, Sept., 1885–1888).

Causes of erosion and methods for repairing tapping notches E. F. Kosolapov (*Metallurg*, 1960, (5), 17–20) [In Russian] The life of such notches fluctuates between 17 and 40 heats in different plants and the time needed for repairs between 1 and 3 h. A review of the different constructions and of repair methods in these plants is given.

Experience with the blowing of metal in acid OH furnaces with compressed air V. A. Kudrin, Yu. M. Nechkin, E. I. Tuyrin, and E. V. Abrosimov (*Metallurg*, 1960, (6), 17–18) [In Russian] Tests were carried out in an 85 t acid OH furnace of 27–28 m² hearth area and 860 mm depth of bath, heated with a mixture of blast-furnace gas and fuel oil. Mainly ShKh15 steel melts were blown with a limited reduction of Si. Duration of boil 2–3 h. The compressed air was fed through 1in dia. iron pipe 4–6 m long at 4–6 atm pressure at a rate of 500–700 m³/h. Carbon combustion increased to 0·75%C/h as against 0·20–0·38%C/h with the normal method. Heat calculations have shown that the heat consumed in heating the air is more than compensated for by that originating from the oxidizing reaction of the admixtures in the metal.

The effectiveness of prepared free flowing materials in the OH furnace process B. G. Petukhov (*Metallurg*, 1960, (8), 11) [In Russian] The OH furnaces at the MMK have used since 1959 large quantities of sinter with an average iron content of 60·5%, with 0·04%S. The free-flowing material contains a high proportion of ferrous oxides and less silica and ferric oxides. Its oxidizing power is less than that of the ore. The melt proceeds smoothly without violent reactions. The quantity of primary slag increases by 5–10% but the quality of the metal is not affected.

Operating the OH furnaces at the MMK E. I. Dikshtein (*Metallurg*, 1960, (8), 11–12) [In Russian] To increase production the charges are increased. A double charge increases productivity by about 40–50%. The capacity of charging and tapping cranes has been increased correspondingly. The hearth area was increased from 65–76 to 73·7 m² but the depth of the bath remained the same at 1 380 mm.

Melting axle steel in large OH furnaces N. V. Keis, O. Ya. Vainshtein, and V. A. Khryukina (*Metallurg*, 1960, (8), 16–18) [In Russian] The necessary mechanical properties for this steel are achieved with a composiion of 0·37–0·42%C, 0·60%Mn, and 0·25%Si. The melting in the 100 and 185 t OH furnaces is described.

Production of high-silicon steels by the acid open-hearth process T. G. Grey Davies (*Iron Coal Trades Rev.*, 1961, **182**, April 21, 833–838) The standard practice followed by Partridge, Jones, and John Paton Ltd, in their production of steel for electrical sheet in acid OH furnaces is described; Ca silicide is used to reduce S-content to a low limit and examples are given to show the effect of this desulphurization by S-silicide additions to the furnace bath and ladle and to the ladle only. Experiments on a 3-t Kaldo vessel with acid lining have shown that acid steelmaking by this oxygen process presents no difficulties and results in less lining wear than that found when operating with a basic lining.—C.V.

Progress in steelmaking—use of basic oxygen steel extended J. K. Stone (*Steel*, 1961, **148**, April 17, 100) A list of 38 specifications for the use of basic oxygen steels—as made by the LD process—listed by the American Petroleum Institute and the American Society for Testing Materials is presented.—S.H.-S.

A practical method for statistical evaluations of open-hearth problems R. A. Hinnebusch and J. A. McKinnon (*AIMME, Proc. OH Conf.*, 1960, **43**, 54–68) The authors present a quasi-statistical method designed to furnish simple graphical solutions to typical shop problems, at a fraction of the effort inherent in a pure statistical approach. To illustrate the method, the authors review work carried out at United Engineering Foundry Co. on the control of Mn recovery from Cr–Mo alloy steels.—G.F.

Analysis of plant operating data using digital computer A. P. Woods (*AIMME, Proc. OH Conf.*, 1960, **43**, 86–128) The author describes a data analysis procedure combining mathematical and graphical regression, which has been developed for analysis by digital computer. The procedure extracts and plots all information on main effects and first-order interactions from a set of operating data. The results are given of a study of 252 OH heats, using a combustion oxygen, roof-lance oxygen practice.—G.F.

Metallurgical aspects of oxygen roof lances F. E. Gribble and W. F. Zepfel (*AIMME, Proc. OH Conf.*, 1960, **43**, 138–142) A three-year investigation at Homestead Works of United States Steel Corp. on the effect of the oxygen roof lance on a variety of products, including carbon and alloy slab, plate, sheet, and rolled and forged bloom, has revealed no adverse effect on steel quality. Details of the investigation are given.—G.F.

New type basic open hearth roof J. W. Flowers (*AIMME, Proc. OH Conf.*, 1960, **43**, 174–182) The author describes a new type of basic roof suspension used at Sharon Steel Corp. The principle is discussed and the design is illustrated. Performance data and corresponding production figures are given.—G.F.

Progress report on the carbon subhearth J. E. Smith (*AIMME, Proc. OH Conf.*, 1960, **43**, 186–191) The author gives a brief progress report on the performance of a carbon subhearth installed in an OH furnace at Republic Steel Corp. Sections of the hearth are illustrated, and temp. changes above and below the carbon blocks are given.—G.F.

Experience with the Maerz-Boelens open hearth furnace A. H. Sommer (*AIMME, Proc. OH Conf.*, 1960, **43**, 195–212) The author discusses the reasons governing the choice of a Maerz-Boelens OH furnace at Keystone Steel and Wire Co. as a means of increasing annual ingot production by 125 000 t net. The design of the furnace is described and illustrated, and furnace performance is outlined.—G.F.

Production of low-carbon, medium-carbon, and high-carbon steels by the basic oxygen process C. C. Benton (*AIMME, Proc. OH Conf.*, 1960, **43**, 215–219) The author gives details of the basic oxygen process in operation at Algoma Steel Corp., emphasizing the flexibility of the process. All grades of carbon steel are produced, and quality has been found to be as good as, or better than, that of OH steel of the same grade.—G.F.

Basic problems in handling materials and products in the basic oxygen furnace process J. N. Albaugh (*AIMME, Proc. OH Conf.*, 1960, **43**, 220–222) Handling problems associated with the basic oxygen process at Aliquippa Works of Jones and Laughlin Steel Corp. are discussed. The factors considered are lime and scrap handling, mould requirements, and ladle and furnace maintenance.—G.F.

Changes made after start-up to increase tonnage and improve quality W. F. Bowers (*AIMME, Proc. OH Conf.*, 1960, **43**, 233–235) As a result of operating experience with the basic oxygen steel process at Kaiser Steel Co., several changes and revisions were made in order to increase efficiency. Details of some of these changes are given, and possible future trends are mentioned.—G.F.

Production advantages from the use of oxygen roof lances O. O. Haniford (*AIMME, Proc. OH Conf.*, 1960, **43**, 236–239) The oxygen roof lance equipment in use at Gary Works of United States Steel Corp. is described, and production data are given to illustrate the advantages of the process.—G.F.

Refractory problems resulting from the use of oxygen lances W. A. Bringman (*AIMME, Proc. OH Conf.*, 1960, **43**, 241–248) The increasing use of oxygen lances in OH steelmaking has resulted in a number of refractory problems. Particular attention is given to the furnace roof and to balancing roof wear and general furnace wear, and the importance of maintenance schedules is stressed.—G.F.

Design problems—oxygen roof lances E. J. Sobey (*AIMME, Proc. OH Conf.*, 1960, **43**, 251–255) Experience at Cleveland Works of Jones and Laughlin Steel Corp. in the development of satisfactory oxygen lances is summarized. The important factors influencing lance design are discussed.—G.F.

Fuels and firing practices with oxygen usage L. T. Sanchez (*AIMME, Proc. OH Conf.*, 1960, **43**, 258–265) The author discusses the application of various firing programmes, with and without the use of oxygen, at Lorain Works of United States Steel Corp. Details of the programmes are given and operating data are compared.—G.F.

Initial linings of basic oxygen furnaces E. R. Richards (*AIMME, Proc. OH Conf.*, 1960, **43**, 268–271) The author describes the basic oxygen furnaces at Acme Steel Co. and gives details of the methods of lining, repair, and maintenance. The refractories used are discussed and the special relining equipment is described.—G.F.

Oxygen steel furnace linings F. C. Muttitt (*AIMME, Proc. OH Conf.*, 1960, **43**, 274–277) Refractory performance during the first 18 months operation of the basic oxygen furnaces at Algoma Steel Corp. is outlined. The most desirable lining features for the particular conditions at Algoma are discussed.—G.F.

Basic oxygen furnace with cupola iron E. R. Richards (*AIMME, Proc. OH Conf.*, 1960, **43**, 229–232) The Acme Steel Co. operates the basic oxygen furnace process with hot metal supplied by hot-blast cupolas. The procedure is outlined and operating experience is given.—G.F.

Problem analysis and data logging on electric arc furnaces J. Brosovic (*ISA Proc.*, 1960, **10**, (4), 1–10) The role data logging and photographic equipment can play in isolating fundamental causes of a serious refractory maintenance problem is discussed and it is shown that an analysis of the data can lead to the development of a simple, periodic, preventive maintenance technique which is capable of reducing the problem to a tolerable level. Examples are illustrated and discussed.—C.V.

The determination of the electrical characteristics of an arc furnace J. Ravenscroft (*Proc. IEE*, 1961, **108**, April, 140–152) Different methods for the determination of electrical

characteristics of arc furnaces are discussed and a comparison is made between three methods each being used in turn with a 10 cwt Héroult-type three-phase arc-furnace. These findings are discussed and it is concluded that a simple locus-diagram treatment gives results of sufficient accuracy for all practical purposes and the characteristics show that the furnace is most efficient, electrically, when operated on the highest voltage tapping. A quite lengthy discussion follows.—C.V.

Plastic refractory linings for electrical furnaces S. Ya. Barin (*Metallurg*, 1960, (8), 15) The refractory mass used for linings must have sufficient plasticity in the raw state, sinter rapidly, and have high strength when sintered. It is prepared from a mixture of 88–94% magnesite powders passed through a sieve of 3 mm mesh and of 6–12% finely crushed refractory clay. This is mixed with waterglass of 1·15 specific gravity to the consistency of a paste.

Adjusting production with an 80 t electric furnace V. K. Petrov and B. V. Barvinskii (*Metallurg*, 1960, (6), 22–24) [In Russian] Some technical characteristics of the furnace are internal dia. 6·30 m, 25000 kVA, secondary voltage 417–131, maximum current 35000 amp electrode dia. 555 mm, and depth of bath 900 mm.

Reconstruction of a 20 t arc furnace S. G. Voinov and A. I. Markelov (*Metallurg*, 1960, (5), 15–17) [In Russian] In 1959 a 20-t arc-furnace was reconstructed according to designs then proposed for the first time. In addition to certain small increases in the earlier dimensions, the chief alteration consisted in replacing the nearly vertical linings by walls sloping at an angle of 39°. Drawings are given. Results obtained with the reconstructed furnace justified further reconstructions.

Fuel and power required for making steel in the electric arc furnace R. S. Howes and A. Jackson (*J. Inst. Fuel*, 1961, **34**, March, 90–92) The data collected for the design of the new Steel, Peech and Tozer electric melting plant at Templeborough is the basis of this paper, and the electrical and thermal efficiency of the proposed plant for the manufacture of rimming and solid carbon steels is considered, with a brief description of the furnaces and the steelmaking process to be used. A heat balance is derived showing the heat usefully applied, defined as heat in the metal and slag and that required to reduce the ore, as 69% of the total potential heat available to the whole operation, including heats of reaction. The combined heat utilization of the Ajax and electric arc furnaces is shown as in the ratio of 58%:42%, giving a thermal efficiency of 72·9%.—S.H.-S.

Use of high alumina refractories in electric arc furnace roofs (*Indust. Heat.*, 1960, **27**, Sept., 1913–1914) Operating and cost comparisons are made between high-alumina and silica roofs.—K.E.J.

Present position of the large-capacity arc furnace in the iron and steel industry—the point of view of the furnace constructor C. Barbazanges (*Rev. Univ.*, Mines, 1960, **16**, Sept., 369–377) Progress made in the large-capacity electric arc furnace for steelmaking is outlined, and several examples of recent installations by S. A. Stein et Roubaix are described.

Present position of the large-capacity arc furnace in the iron and steel industry—the 80-t electric arc furnace of the Société des Usines Saint-Jacques á Montluçon P. Sauvage (*Rev. Univ. Mines*, 1960, **16**, Sept., 378–383).

Present position of the large-capacity arc furnace in the iron and steel industry—the point of view of the supplier of electrical energy M. J. Chanzy (*Rev. Univ. Mines*, 1960, **16**, Sept., 384–389) The author examines in detail the effects of the connexion of large capacity electric arc-furnace on the grid distribution. Technical and tariff problems are discussed.

Present position of the large-capacity arc furnace in the iron and steel industry—operation of the large 80-t arc furnace in the steel works at Breuil of S.F.A.C. J. Colin (*Rev. Univ. Mines*, 1960, **16**, Sept., 389–400).

Present position of the large-capacity arc furnace in the iron and steel industry—The new electric plant of Steel, Peech and Tozer R. S. Howes and A. Jackson (*Rev. Univ. Mines*, 1960, **16**, Sept., 400–408) Factors influencing the decision to replace the existing open-hearth plant with electric arc-furnaces are discussed, economic aspects of the changeover are outlined and lines of development of a steelworks intended to work with 100% scrap are indicated.

Present position of the large-capacity arc furnace in the iron and steel industry—the electrical supply to high-power electric arc furnaces M. Verhoeven (*Rev. Univ. Mines*, 1960, **16**, Sept., 408–414) Electrical supply problems are discussed from the Belgian standpoint, with particular reference to the 150-t furnace of Fabrique de Fer de Charleroi.

Steelmaking with oxygen. The LD, Kaldo and OLP processes H. Lecompte (*Arts et Manuf.*, 1960, (104), Dec., 72–74).

The refining of Thomas pig iron in the oxygen top-blowing process E. Plöckinger, M. Wahlster, K. Borowski, J. Maatsch, A. Schildkotter, and V. Schiel (*Techn. Mitt. Krupp*, 1960, **18**, Dec., 97–108) A detailed account of the development of the top-blowing O_2 processes, including a discussion of problems connected with the blowing of high-P irons, and a description of the dynamic processes within the O_2 jet and of the glass flow within the LO vessel. Experiments were carried out in a 3-t vessel, and later 60-t blows were made, using a modified process whereby the reactions were controlled by regulating blast jet conditions to achieve a correct temp. and composition of the gas mixture at the reaction surface. Tap-to-tap times of 45 min were obtained. Lump lime is used, with a constant distance of the lance from the bath (22 refs).

LD and basic lined side-blown converter K. N. Gupta and B. Prakash (*NML Pilot Plant Symp.*, 1960, July, 113–118) The LD process and side-blown converter operations are described, with descriptions of plants, data on tests, and results obtained and tabulated, with a brief discussion.—S.H.-S.

Cooling of open-hearth furnaces by evaporating water J. Altneder (*Koh. Lapok*, 1961, **94**, March, 109–113) Cooling experiments with evaporating water were carried out on a skew-back channel and a door frame of an OH furnace at the 'Duna' Steelworks in Hungary. After satisfactory results, this method was introduced to all furnaces. Cooling with evaporating water appears to be more reliable than cooling with circulating water. However, some alteration is still necessary to avoid failures.—P.K.

Future trends in modern steel-making industry K. Razdzwicki (*Hutnik*, 1961, **28**, (4), 148–153) Pneumatic processes could make the OH process uneconomic except for very large units of 700 to 900 t fired with O_2, as this would allow for another 25% increase of production and a saving of 10 to 15% of heat. As the pneumatic process cannot use more than 20% scrap, it is particularly suitable for countries which have no steel industry, or have to rely on imported scrap. Where cheap electric energy is available, large electric arc furnaces of capacities up to 250 t equipped with transformers up to 50000 kWh could produce steel not only cheaper than the OH, but also of better quality, since the melting can be carried out in a vacuum, dissolved gases being thus removed.

Rourkela Steelworks: German contribution to India's industrial development L. Walter (*Iron Steel*, 1960, **33**, Sept., 446–451).

The construction and installation of side-blown basic converters Yang Dung and Whang Ching-shen (*Iron and Steel*, 1959, (3), 83–86; from *Sci. Abs. China, Techn. Sci.*, 1959, (2), 76) Improvements in design and construction are suggested after inspection of a 3-t converter after use.

Pilot plant for the oxygen top blowing process with a 3-t crucible K. Borowski (*Techn. Mitt. Krupp*, 1960, **18**, Dec., 109–114) A description of the experimental plant used at Krupps, Essen, and consisting of a rotary furnace premelting unit supplying a 3-t crucible, and incorporating an experimental dust removal plant. Operation and control equipment are described.

Oxygen and mixtures of oxygen and steam used in open hearth practice V. F. Bogatenkov (*Stal'*, 1961, (6), 518) A note from Chelyabinsk. A blowing process removing Si without forming brown fumes has been developed. Blowing time is shortened and fuel consumption reduced 6%.

On the design of open-hearth burners V. Bulina (*Hutník*, 1961, **11**, (4), 166–168) [In Czech] As a result of the present construction of large oil-fired OH furnaces in Czechoslovakia, special interest has been focussed on high-pressure burners. The main features of burners now being designed are discussed.

Experience with oil fired open-hearth furnaces L. Milata (*Hutník*, 1961, **11**, (4), 161–165) [In Czech] Advantages attained by the replacement of producer gas by oil in 50-t all-basic furnaces in the Klement Gottwald Steelworks, Ostrava, are discussed. The decisive influence of burner design on furnace performance is considered.—P.F.

Results on the use of oil containing 1·8% of sulphur in open-hearth furnaces of the Kladno Steelworks L. Šeffl (*Hutník*, 1961, **11**, (4), 165–166) [In Czech] Experiments on a works scale confirmed that high-sulphur oils are in principle usable provided that increases in the steel refining time and other sources of extra cost do not annul the savings attained by the use of cheaper oils.—P.F.

Intensification of open hearth process by compressed air. A lecture N. I. Shirokov (*NML Pilot Plant Symp.*, 1960, July, 279–286).

Oxygen in open hearth steel-making J. W. Kirkpatrick (*AISI preprint*, 1961, pp.35).

On the problem of raising the output of OH furnaces A. D. Klyuchnikov (*Stal'*, 1961, (6), 564–565) Notes on a paper by Glinkov and Glinkov (*Stal'*, 1956, (6)). Furnace dimensions and proportions are considered.

Reply to the comments on A. D. Klyuchnikov M. A. Glinkov and G. M. Glinkov (*Stal'*, 1961, (6), 566) The analysis presented is claimed to have limited validity and the practical suggestions are not in contradiction to the principles of the original paper.

On reserves for increasing labour productivity in open hearth production A. F. Zakharov, G. A. Petrov, M. D. Novikov, L. P. Popov, Yu. V. Torshilov, S. N. Gologhmatov, A. N. Gusarov, and N. P. Koval'chuk (*Stal'*, 1961, (6), 560–562) The conclusions of Sobolev and Gershogorin on reduction of OH cold repair time are disputed. Methods at NTMK are described and improved organization and mechanization are advocated. The Editorial Board of *Stal'* supports these contentions.

Melting naturally alloyed steel R. M. Ivanov (*Stal'*, 1961, (6), 518) A note from Chelyabinsk and the Orsk-Khalilovo combine. In a duplexing process, addition of 1·5% scale to slag during melting improves P removal. Deoxidizing practice is also considered.

The technical problems of the steel plant at Bona M. Vicaire (*Mines Met.*, 1960, Nov., 641) The prospects for the new steelplant at Bona (Algeria) with a planned output of 500000 t per annum of electric furnace steel and a personnel of 3000–4000 in two or three years' time is discussed, with economic and technical data.—S.H.-S.

Iron production in the electric furnace J. Astier (*Arts et Manuf.*, 1960, (104), Dec., 68–71).

Fundamental study of automatic control. I. Temperature measurement of electric arc furnace (*Denki-Seiko*, 1960, **31**, May, 125–129) [In Japanese] [No Summary].—K.E.J.

Checking characteristics of electric arc furnaces J. Ravenscroft (*Elect. Times*, 1960, **138**, Dec. 15, 923–924; from *IEE paper* 3328) It is suggested that the direct method has limited application for production furnaces and that if a series of short circuit tests can be made to determine furnace constants, without interfering too much with production, the complete characteristic can be derived by calculation using a simple formula. This is discussed and examples are given.—C.V.

Electrical circuits in three-phase arc furnaces I. T. Zherdev (*Nauchnye trudy, Dnepropetrovakii metallurgicheskii institut*, 1959, **40**, 5–18) A method is suggested for calculating non-sinusoidal currents and tensions of three-phase circuits, containing electrical arcs, suitable for

simplified equivalent diagrams of arc steel-making furnaces (9 refs). **An asymmetrical electrical circuit of a three-phase arc furnace** (25–32) The method suggested enables theoretical investigation of phenomena in asymmetrical circuits of three-phase arcs. Calculations of asymmetrical curves of instantaneous values of currents and tensions of currents of three-phase arcs can be carried out for cases of failure of symmetry because of phase inequality of active and induced resistances, and also because of inequality in arc tensions (5 refs).—A.I.P.

Production of steel in arc furnaces with electromagnetic stirring of the bath S. M. Gnuchev, V. I. Trakhimovich, A. F. Tregubenko, V. P. Frantsov, and T. M. Bobkov (*Stal'*, 1961, (6), 519–522).

The effect of scrap quality on the power consumption on melting in arc-furnaces M. Keberle (*Slévárenství*, 1961, **9**, (4), 148–149) [In Czech] Efficient scrap utilization was studied in experiments with a 5-t arc-furnace melting plain carbon steels. The composition, piece-size, and quantity of scrap per charge, were the principal variables considered.—P.F.

Loss of aluminium on deoxidizing plain carbon steels in the arc-furnace P. Fremunt K. Stránský (*Slévárenství*, 1961, **9**, (4), 126–131) [In Czech] Loss of Al in deoxidizing cast basic carbon steels in the production of castings of up to 2in wall thickness is discussed on the basis of experiments. On deoxidizing in the ladle, Al losses are appreciably below those occurring on deoxidizing in the furnace.—P.F.

The production of semi-killed steels for sheet of medium thickness in the Šverma Steelworks in Podbrezová M. Gavenda and J. Turoň (*Hutník*, 1961, **11**, (5), 236–237) [In Czech] Details of the method of making Al additions to the runner in the production of ingots weighing $\frac{3}{4}$ to $3\frac{1}{2}$ t are given, and the problem of ingot defects is discussed.—P.F.

Some features of the use of molybdenum in alloy steels (*Aciers Fins Spéc.*, 1960, Dec., 21–32).

Production of non-ageing low-carbon, low-silicon electrical steel N. P. Zhetvin (*Stal'*, 1961, (6), 522) A note from 'Serp i Molot'. The method of production is briefly outlined.

Improving the production of EI347 steel for bearings M. I. Vinograd, M. S. Goncharenko, V. M. Doronin, V. V. Topilin, B. G. Chernina (*Stal'*, 1961, (6), 543–546) Various modifications were tried and the best method found reduced rejects to below 2%.

Alloying manganese steels with chromium ore P. Fremunt and P. Pant (*Slévárenství*, 1961, **9**, (4), 146–147) [In Czech] The use of Cr ore instead of Fe–Cr was found to be suitable for alloying low-alloy steels, leading to significant savings. Analyses are given, and procedure is discussed.—P.F.

The increase of the life of ingot moulds L. Gombás (*Koh. Lapok*, 1961, **94**, May, 219–223) The effect of the design, chemical composition, and distribution and size of graphite and other constituents on the life of ingot moulds is discussed. Various welding methods for mending eroded places on the surface of ingot moulds and steels to increase life are also described.

The kinetics of ingot to mould heat transfer F. Havlíček (*Sborník* (*Ostrava*), 1960, **6**, (8–9), 841–854) [In Czech] The temp. distribution in the ingot, the mould, and the gap forming between the ingot and the mould on solidification is studied mathematically as a function of the cooling time.—P.F.

Heat conservation in the feeder heads of 2·6 and 4·5 ton ingots using lightweight firebrick Yu. D. Smirnov (*Stal'*, 1961, (6), 518) A note from Chelyabinsk. A new hot-top design using a lining of lightweight firebrick increases yield 2–4%.

Semi-killed and capped steels Ya. A. Shneerov (*Stal'*, 1961, (6), 516–518) A report of a conference held in Feb. 1961. Practice at numerous plants and recommendations of the conference are discussed.

Development of a process for semi-killed steel N. P. Zhetvin (*Stal'*, 1961, (6), 518) A note from Serp i Molot. Al powder is added to the moulds after filling at the rate of 0·3 kg/ingot of Sv–08 steel. This semi-killed steel may replace killed metal.

On the influence of small additions of aluminium on the austenite grain size Z. Rusňák, K. Stránsky, and M. Králova (*Slévárenství*, 1961, **9**, (4), 138–143) [In Czech] Al additions of 0–800 g/t, resulting in total contents of 0·002–0·037% were made to several melts of steels having the approximate composition 0·25%C, 0·70%Mn, 0·35%Si, 0·02%P, 0·02% S, and the resulting grain refinement was investigated. The theoretical and practical implications of the data are discussed.—P.F.

Bottom pouring of rimming steel with the metal fed into the ingot stool side A. N. Lekontsev (*Stal'*, 1961, (6), 514–516) The development of a new stool is described, it gives ingots with pyramidal or rounded bottoms eliminating bottom discard and increasing yield 4–6%.

Stationary states in a rimming steelmaking bath E. M. Ogryzkin (*Izvest. AN Otdel Tekhn. Met. i Toplivo*, 1961, (2), 31–42) A lack of balance between carbon of the metal and oxidizing capacity of the slag and the metal of a rimming steelmaking bath is the result of the setting up in the bath of a state close to a stationary state, and not the result of a delay in the process of supplying oxygen for the decarburizing process. Implications are examined (12 refs).—A.I.P.

Investigations of decreasing the harmful segregation in rimming steel. Part II. Cooling treatment by blowing oxygen or compressed air and by inserting steel sheet during solidification of the large No.3 steel ingots Hsao Shiang-hwa, Hoo Ven-gan, and Pan Yue-chu (*Acta Met. Sin.*, 1948, **3**, (4), 276–289; from *Sci. Abs. China Techn. Sci.*, 1959, (2), 71) O_2 blowing of 10 t ingots, cooling with sheet steel of 7·1 t ingots, cooling 10·7 ingots with a heavier plate (298 kg) and other processes were tried. Mechanical properties as cast and after rolling were also measured.

Continuous casting J. Duflot (*Arts et Manuf.*, 1960, (104), Dec., 78–80).

Continuous casting development for steel. I. M. D. Halliday (*NML Pilot Plant Symp.*, 1960, July, 253–265) A survey is presented which lists and tabulates in two groups :(I) experimental and pilot plants operating subsequently to World War II and some of them now defunct; and (II) four more active groups, amounting to 34 plants in number, which are described as Russian; German-Austrian; BISRA, with the Charleroi plant as Belgian associate; and, not least, the Rossi-Barrow-Concast group. After a general description of the operations of the two main groups, a brief description of the Barrow practice is presented.—S.H.-S.

Continuous casting of high grade steel B. Tarmann (*Iron Steel Rev.*, 1960, *Tata No.*, 215) The Bohler continuous casting system is briefly described.—S.H.-S.

The continuous casting of special steels B. Tarmann (**Radex Rund.*, 1961, June, 579–589) [In German] Various examples are given of the use of continuous casting machines for the production of special steels. The conditions required for continuous casting, the characteristics of continuous cast special steels including defects which occur and the economies of the process are described.

One of the largest continuous casting plants in the world (*Aciers Fins. Spéc.*, 1960, Dec., 33–43) The layout, construction, and operation of the continuous casting plant at SAFE are described.—R.P.

Study of heat transfer in the mould of continuous-casting machines for steel A. D. Akimenko and A. A. Skvortsov (*Izvest. VUZ Chern. Met.*, 1958, Dec., 45–50) The most important limiting factor on the production rates achieved with continuous casting machines is the overall heat transfer coefficient from the steel to the cooling water. The effect of the air gap formed between the solidifying steel and the mould wall is discussed, and results given for the gas composition in this gap. The gap is found to contain large concentrations of hydrogen, from decomposing lubricants, and these markedly affect the heat transfer.

The structure of a continuously cast rimming steel slab G. M. Itskovich and V. B. Gankin (*Stal'*, 1961, (6), 505–514) Solidification phenomena are reviewed and the structure, and chemical and metallographic uniformity of shell and core are examined and compared with the conventional ingot. Greater uniformity is found for causes which are elucidated, and satisfactory rolled sheet can be produced.

Ground type stripping machine with floating shaft I. S. Lyulenkov and S. P. Kochnev (*Stal'*, 1961, (5), 478–479) A new type of ingot stripper with eccentric shaft is described. This machine takes 22 sec to strip large ingots with a force of up to 600 t. A similar device for smaller ingots could be designed.

Study of the melting of transformer steel in an arc furnace N. F. Dubrov, I. A. Gorlach, and S. S. Privalov (*Stal'*, 1961, (5), 403) A note from the Ural Sci. Research Inst. Addition of up to 6% ore and up to 3% lime reduced Mn to 0·1% and Cr to 0·03%. Lancing with pure O_2 reduces C to 0·03–0·04%. Alloying with Si improves S removal as does the use of a framing slag with $\geqslant$1·5–2%FeO. Si–Mg for deoxidation reduces O_2 by 15–20%.

Integrated electric steelmaking based on nuclear power G. Zuliani (*J. Four. Elect.*, 1961, **66**, March, 85–88) [In French] The economic development of the blast-furnace and the increasing use of electric energy for the reduction of iron ore and the conversion of iron to steel is described. It is calculated that a nuclear power station of 165 mW corresponding to thermic power of 660 mW could produce 750 000 t of steel a year.

Aluminium capped steel W. P. Connor and D. J. Miller (*AIMME, Proc. OH Comm.*, 1960, **43**, 4–19) A comprehensive comparison of fully-rimmed and Al-capped deep-drawing steel has been made at Cleveland Works of Jones and Laughlin Steel Corp., an ingot of each type from one heat being sectioned for examination and a companion pair of ingots rolled to sheet. The factors compared are segregation and macrostructure to the ingots, and the yield, surface quality, physical properties, and microstructure of the finished sheet. Production and cost features are also considered. Al-capped steel is shown to be quite satisfactory for deep-drawn parts, and affords a 2% higher yield.—G.F.

Production of low-alloy converter rail steel M. A. Gershgorn, D. S. Kazarnovskii, I. G. Filonov, A. D. Kutsenko, and D. P. Ul'yanov (*Stal'*, 1961, (5), 404–408) A method minimizing the use of alloying elements while producing durable rails is described on the basis of small and large-scale trials. Small numbers of inclusions spheroidal in shape are encountered, N_2 and O_2 contents are low, and ores are used rather than ferro-alloys or concentrates.

The production of thick semi-killed steel plates S. Ya. Skoblo (*Stal'*, 1961, (5), 414) Deoxidation with Fe–Mn(=0·35–0·6%Mn), Fe–Si (=0·12–0·14%Si) and Al (100–120 g/t) is used and 10–52 mm plate is rolled direct from the ingot.

The effect of nickel on the chromium and carbon relationship in stainless steel refining A. Simkovich and C. W. McCoy (*Trans. Met. Soc. AIME*, 1961, **221**, April, 416–417) A simplified version of the relationship developed by Hilty is given by $\log \%Cr/\%C = -13\,800/T + 8{\cdot}76$ where the equilibrium concentration of C and Cr in the liquid metal at O_2 saturation is expressed as weight per cent and T is the absolute temp. of the bath in °K. A summary of chemical analyses and measured and calculated temp. is given and a close agreement would appear to be found. Initially this equation related to plain Cr-steels; in the table six alloy groups are dealt with the Ni content being zero and ~4, 8·5, 12, 16·5, and 20%. A further modified equation is given in which closer T values are found.—C.V.

Concerning the production of transformer steel S. M. Gnuchev, D. G. Zhukov, N. V. Keis, Z. V. Klochkova, P. M. Danilov, and K. N. Konovalov (*Metallurg*, 1960, (6), 18–22) [In Russian] A survey of the technology of melting transformer metal at different works.

How to make additions to improve the ductility of cast steel J. Gibinski and W. Jarocki (*Prz. Odlew.*, 1961, **11**, (4), 113–116) Three methods of making additions have been tried, and method C has been found the most effective. The Fe–Mn is put into the converter, while the carburizer and 1/3 of the Al required, are

placed in the bottom of the ladle. The ladle is filled to one-third, 1 min is allowed to elapse, and when the ladle is half-full, the Fe–Si and the remaining 2/3 of the Al are added. Analysis of the blown metal: 0·02–0·09%C, 0·03–0·10%Mn, 0·04–0·06%Si, 0·08%P, 0·06%S, and of the cast steel: 0·22–0·30%C, 0·50–0·80%Mn, 0·17–0·37%Si, 0·80%P, 0·06%S.

Increased life of closed-bottom moulds V. S. Krasovitskii, E. K. Turchenkova, and R. M. Egnus (*Stal'*, 1961, (5), 475–476).

A new method of dressing ingot moulds with petrolatum G. A. Khasin, P. P. Menushenkov, A. K. Petrov, B. P. Okhrimovich, V. N. Davidyuk, S. K. Filatov, P. V. Vasil'ev, M. V. Loktionov, and Yu. G. Gurevich (*Metallurg*, 1960, (5), 21–24) [In Russian] A new method of dressing ingot moulds has been introduced at the Zlatoust Metallurgical Works. It consists of placing pieces of dry petrolatum or paraffin and other similar substances on the bottom of the mould before filling. These melt at once and the liquid spreads over the rising metal meniscus, evaporates, and ignites. Because there is insufficient oxygen in the mould, reducing gases are formed and carbon is deposited in a uniform layer on the walls of the mould. Results are especially satisfactory with stainless steel.

Use of chemically bonded hot tops at Lukens D. E. Grimme and D. K. Matthews (*AIMME, Proc. OH Conf.*, 1960, **43**, 162–170) Lukens Steel Co. has recently adopted a new hot-topping practice in which sand hot-tops are rammed *in situ* around a collapsible former, and hardened by the CO_2-silicate process. The hardening process is discussed and the manufacturing facilities are described. Indications are that a 1–2% improvement in yield can be obtained over the previous cement hot-top.

Internal stresses in ingot moulds H. Bühler (*Stahl Eisen*, 1961, **81**, March 2, 327) The author in collaboration with E. Herrmann studied the internal stress conditions in ingot moulds made of grey cast iron. The moulds were then also tested by methods given by F. Stäblein and by R. G. Treuting and W. T. Read. The results obtained are discussed.

Teeming high-alloy steels V. P. Osipov, V. A. Efimov, P. A. Matevosyan, V. I. Danilin, M. P. Lapshova, V. M. Selivanov, and I. V. Lisov (*Stal'*, 1961, (5), 415–418) Use of synthetic slag capable of dissolving the oxides formed greatly improved the surface quality of cast steel. No effect on corrosion resistance was produced.

Quality control of ladle refractories R. E. Hawster (*Indust. Heat.*, 1960, **27**, Sept., 1933–1934) Quality control is based on visual examination, cross-sectional cuts to check voidage or lamination, and evaluation of porosity, refractoriness, bulk density, and size. Testing of analysis, rupture modulus, and reheat of ladle brick, and sonic testing, are considered.—K.E.J.

Ladle lining practice for basic oxygen steel B. L. Dorsey (*AIMME, Proc. OH Conf.*, 1960, **43**, 279–282) The introduction of the basic oxygen process at Aliquippa Works of Jones and Laughlin Steel Corp. necessitated an improvement in ladle lining performance. The development of an improved practice is discussed, and performance data are given.

The spiral method of laying brick linings in 200 ton steel ladles N. A. Roklin (*Stal'*, 1961, (5), 412) Bricks laid in an ascending spiral from the bottom, using, in part, a special wedge-shaped brick, by a process described hastens the work by 36% and saves the use of key bricks. The process is recommended for general adoption.

Remote control of the stoppers of the teeming ladle P. K. Morokov (*Metallurg*, 1960, (8), 14) [In Russian] A system of hydraulic remote control of the two-stoppered 200–260 t teeming ladles at the KMK is explained. Drawings are given for the three possible combinations.

Continuous casting research at BISRA and CNRM G. Fenton, G. Littlewood, and J. Zaeytydt (*Iron Coal Trades Rev.*, 1961, **182**, March 31, 681–685).

Improvement in mould design in continuous casting plants V. P. Druzhinin and A. I. Mazun (*Stal'*, 1961, (5), 409–411) Various improvements of design, lubrication, and causes of sticking are described. The walls deform in a regular manner, preventing sticking.

PRODUCTION OF FERRO-ALLOYS

Experimental investigation of current density of the charge materials of ferroalloy furnaces I. T. Zherdev and V. N. Davatts (*Nauchnye trudy, Dnepropetrovskii metallurgicheskii institut*, 1959, **40**, 33–42) The presence was experimentally confirmed of currents in the charge materials of a ferroalloy furnace melting 45%Fe–Si. For the first time the presence was objectively established of the presence of currents in charge materials of ferroalloy furnaces melting 75%Fe–Si and Si–Mn. **A simplified method of measuring current density of charge materials in a ferroalloy furnace** (43–47) As opposed to a previously published method using two probes, the current density of charge materials in a ferroalloy furnace can be measured with the aid of a single probe. This single-probe method is more rational for measuring current density of the charge immediately adjacent to the furnace electrode. **Measurement of current density in the melt of an electric corundum furnace** (49–54) A method is described of measuring current density of the melt of an electric corundum furnace, with appropriate alteration to probe construction, to increase operational reliability which can be used for more detailed study of current distribution in the furnace chamber.—A.I.P.

Concerning the problem of the choice of basic geometrical measurements of a ferroalloy furnace I. T. Zherdev and T. A. Zanuzdannyi (*Nauchnye trudy, Dnepropetrovskii metallurgicheskii institut*, 1959, **40**, 55–71) The method suggested makes it possible to choose geometrical parameters which, together with high resistance, will achieve greatest distribution of potentials and currents in charge materials in the furnace. Further work is recommended to simplify methods of calculation (7 refs).

Increasing ferro-manganese production for the T.M.P. S. N. Sircar (*Iron Steel Rev.*, 1960, *Tata No.*, 135–143) A review of Indian Govt. plans for starting up of nine Mn plants in different parts of the country between 1956 and 1961, with an overall capacity of about 172 000 t of Fe–Mn per annum by the electric process, with relevant data as to equipment and its origin, is presented.—S.H.-S.

Smelting of 75% ferrosilicon with a low aluminium content Kh. N. Kadarmetov (*Stal'*, 1961, (6), 575) A note from Chelyabinsk. Using sulphur-containing oil-coke fines instead of coke fines reduced Al nearly to half, but magnetic properties were scarcely improved.

Low-manganese ore in the smelting of silicomanganese Kh. N. Kadarmetov (*Stal'*, 1961, (6), 575) A note from Chelyabinsk and the Siberian Met. Inst. Dzhezdinsk ore enriched up to 22%Mn is satisfactory. Use of the unenriched ore is not economic.

The effects of lime and fluorspar on slag viscosity in the production of silicochrome N. L. Zhilo (*Stal'*, 1961, (6), 525) A note from Chelyabinsk. Addition of CaF_2 lowers viscosity in slags with 30–35%SiO_2.

Single-stage smelting of silico-chrome from chrome ore and quartzite Kh. N. Kadarmetov (*Stal'*, 1961, (6), 575) A note from Chelyabinsk. Coke breeze is used without charcoal or CaF_2 with a slag of 40–90%SiO_2, and MgO and Al_2O_3 about equal.

Prolongation of the campaign in the production of silicocalcium A. N. Rabukhin, E. B. Radomysl'skii, and V. I. Vikulov (*Stal'*, 1961, (6), 523–525) Use of a rotating bath furnace is described, its electrical and mechanical specifications being given and operational factors indicated. Rotation should begin after 3–4 days. It is expected that savings will result from the production of Si–Ca in such a furnace.

FOUNDRY PRACTICE

Practical foundry testing E. Heap (*Castings*, 1961, **7**, May, 9–15).

The role of structure in the evaluation of cast iron A. Collaud (*Koh. Lapok-Öntöde*, 1961, **12**, April, 73–81; May, 97–104) According to Patterson's equation $\alpha = \sigma_B/\text{EoHB} \times 10^{-5}$ the higher the tensile strength (σ_B) and the lower the Brinell hardness (HB) the better is the quality (α). Young's modulus (Eo) being practically constant. The effect of heat-treatment, structure, and other factors on the tensile strength, Brinell hardness and bend properties of cast iron is discussed.—P.K.

Inside the TELCO foundry division N. K. Chekravarty, *Iron Steel Rev.*, 1960, *Tata No.*, 185–191) The foundry, its equipment, and operation, are described.—S.H.-S.

Present state and future prospects of development of the Šmeral Foundries V. Šteffek (*Slévárenství*, 1961, **9**, (4), 122–125) [In Czech].

Construction and operation of a water-cooled cupola R. Sato and K. Sato (*Imono*, 1960, **32**, Oct., 722–728).

The B.C.I.R.A. experimental cupola installation H. J. Leyshon and R. I. Higgins (*NML Pilot Plant Symp.*, 1960, July, 271–278).

Planning the grey-iron foundry. (T.I.S. No.2) G. G. M. Carr-Harris (*Technical Information Service Canada*, 1952, pp.14; from *DSIR, TIDU* 1961).

Metters bath foundry J. B. Clarkson, F. Spring, and G. Whitney (*Castings*, 1961, **7**, April, 17–21).

The relation of blast quantity and combustion ratio in cupola operation K. Ishikawa, I. Saeda, and T. Suzuki (*Imono*, 1960, **32**, Sept., 619–624).

Control of air flow to the cupola. The different measuring instruments (*J. d'Inf. Tech. Indust. Fonderie*, 1960, (121), Nov.–Dec., 1–5).

On the use of calcium carbide in the cupola of the Šmeral Foundry M. Keberle (*Slévárenství*, 1961, **9**, (4), 151–152) [In Czech] Preliminary tests showed that additions of CaC_2 in amounts of 1–3% of the total charge result in economies on melting grey cast-iron. The extra expenditure of fuel entailed by the use of carbide is more than compensated for by economies facilitated by using a higher proportion of steel scrap in the charge.—P.F.

Studies on the melting condition of manganese pearlitic malleable iron M. Suzuki, A. Hiramatsu, and N. Tsutsumi (*Imono*, 1960, **32**, Sept., 625–635) An acid-lined Heroult furnace was used to refine cupola iron. Pinholing effects and mottling are discussed.

Grey iron for castings: Development of standard UNI 668 G. Cola (*Fond. Ital.*, 1961, **10**, (4), 113–120) [In Italian] The new standard meets a need to test the castings rather than specimens without sacrificing the international standard, which is based on the use of the standard specimen.

The production of black heart malleable castings R. Lamm (*Koh. Lapok-Öntöde*, 1961, **12**, May, 105–110).

The effect of thickness on the structure of cast iron M. Hajtó (*Koh. Lapok-Öntöde*, 1961, **12**, April, 82–84).

Good design pays off in zinc and grey iron castings (*Met. Prog.*, 1960, **78**, Dec., 122–123)

Improving the quality of cast iron for ingot moulds P. G. Berezin, V. I. Danilin, A. A. Everev, S. S. Elistrator, F. F. Zamechnik, P. P. Redin (*Stal'*, 1961, (6), 571–575) Statistical data from 4000 closed bottom moulds is used to arrive at optimum composition and structure. The moulds should be ferritic–pearlitic approximating to the eutectic with a hardness of 140–150 Brinell.

Pressure-tight grey-iron castings C. F. Walton (*Mach. Design*, 1961, **33**, March, 162–164).

The influence of nitrogen on graphite shape in titanium cast iron Y. Ueda (*Imono*, 1960, **32**, Oct., 696–702) Ti forms first TiN and then TiC, if Ti:N is >4, TiN gives way to TiC which may dissolve N_2. TiN is associated with flake graphite and TiC with eutectic graphite. Tensile strength and hardness are low in two-component areas, high with flaky or eutectic graphite alone.

Nodular iron gears J. A. Edwards (*Iron Steel*, 1960, **33**, 459–461).

On the shrinkage defects of spheroidal graphite cast irons treated with various spheroidizing reagents H. Nakamura and T. Takase (*Imono*, 1960, **32**, Oct., 703–712).

Applications of ductile irons T. W. Curry (*Ironworker*, 1961, **25**, Spring, 22–31).

Improved steelmaking practices enhance the mechanical properties of high strength steel castings J. Zotos and K. D. Holmes (*PB* 149560, 1960, May, pp.26; *Rept. RPL* 10/25; from *US Res. Rep.*, 1960, **34,** Dec. 16, 760).

Constructional steels for low alloy castings G. Violi (*Fond. Ital.*, 1961, **10,** (4), 121–132) [In Italian] The extended use of high-quality steel castings in mechanical construction depends mainly on the solution of quality problems. This article examines the function of the alloying elements in high quality castings and the correlation between the microstructure obtained by heat-treatment and mechanical properties. There is a significant correlation between mechanical properties of steels with tempered martensite microstructure and in this connexion the possibility of establishing quality indices is suggested.

Improvement of the casting properties of steel EI 319 N. P. Zhetvin (*Stal'*, 1961, (6), 570) A note from 'Serp i Molot' and TsNIIT-MASH. α-phase should amount to 0–10% and a rapid ferrite meter is used to indicate the need for ferrite formers (Cr or Si).

Some aspects of the production of cast-steel axlebox bodies J. McConnell (*Brit. Found.*, 1960, **53,** Nov., 469–476).

On the compression rate in high temperature tests of moulding sand M. Mutaguchi (*Imono*, 1959, **32,** Oct., 685–689) The clay substance which is added to the moulding sand in the mould as the binder turns into the plastic state when steel or cast iron is cast. When a substance is deformed in the plastic state the compressive stress varies with the compression rate. In this paper the relations between compressive stress and compression rate are investigated using a specimen of foundry sand bonded with bentonite. As the result, it is found that the compressive stress of the sand specimen is remarkably improved with the increase of the compression rate. The effects of the second binder are also investigated.

Anomalous expansion during the cooling of clay-bonded silica sand J. Goodison and J. White (*Brit. Found.*, 1960, **53,** (11), Nov., 477–479).

The problem of flow properties of synthetic moulding sands L. Lewandowski (*Prz. Odlew.*, 1960, **10,** (11), 304–316) In this article the results of research to establish the most suitable and general fluidity criterion involving such factors as homogeneity and others are given.

The reclamation of used sand A. Torlach (*Iron Steel*, 1961, **34,** May, 181–182).

Toward a science of gating castings J. G. Kura (*Battelle Tech. Rev.*, 1960, **9,** Dec., 3–7) A gating system is defined and the essential requirements are given; turbulence must be reduced, air entrainment must be eliminated, velocity must be decreased, the mould must be filled fast enough to prevent premature freezing causing defects, thermal gradients must be assisted so that shrinkage cavities can be filled with molten metal from risers and reproducibility must be attained. Various illustrations are provided relating to these points.—C.V.

On the shape and setting position of the shower gate N. Kayama, K. Ri, and H. Okita (*Imono*, 1960, **32,** Oct., 690–695).

Exothermic riser charges L. Rotter and M. Mareš (*Slévárenství*, 1961, **9,** (4), 153–154) [In Czech] The use of SiC base exothermic mixtures in risers on large castings is shown to lead to savings, mainly through a reduction in the consumption of liquid steel.—P.F.

Grey iron sand and die castings Qualcast Ltd (*Times Rev. Indust.*, 1961, April 22).

The use of a portable electric mould-drier in steel and grey iron foundries W. Annen (*Electrowärme*, 1960, Nov., **18,** 352–356) Conventional drying furnaces are compared with portable electric mould driers. Electric driers offer the advantage of requiring less energy and reduced drying times.—R.P.

The influence of curing temperature of bentonite clay from Gorki near Pinczow on its binding properties J. Szreniawski (*Prz. Odlew.*, 1960, **10,** (11), 301–304).

Steel castings made in CO_2-hardened bentonite mixtures L. Rotter (*Slévárenství*, 1961, **9,** (4), 149–151) [In Czech] Synthetic mould mixtures containing 16% of loam were displaced by chemically hardened bentonite mixtures in the production of grey-iron castings weighing up to 4½ t. Considerable improvements resulted, and productivity increased appreciably. The composition of the mixtures used and the technology of castings are discussed.

Increasing the efficiency of liquid steel utilization R. Pauliček (*Slévárenství*, 1961, **9,** (5), 190) [In Slovak] The redesign of conventional shapes of castings and the utilization of power station grit as heat insulant are cited as examples of measures leading to a saving of steel in the foundry. Specific cases are discussed.—P.F.

Casting small castings of Hadfield steel into chemically hardened green moulds containing coal dust L. Rotter (*Slévárenství*, 1961, **9,** (4), 152–153) [In Czech].

Sloping casting in the steel foundry W. Sachse (*J. d'Inf. Tech. Indus. Fonderie*, 1960, (121), Nov.–Dec., 11–15; from *Geissereitechn.*, 1959, Nov.).—S.H.S.

GKI&S ingot-mould foundry Guest Keen Iron & Steelworks (*Found. Trade J.*, 1961, **110,** May 18, 625–631).

Big investment castings. II. How they are made H. Lefer (*Prec. Met. Mold.*, 1960, **18,** Dec., 34–35).

Sintered alumina moulds for investment casting of steels F. C. Quigley and B. Bovarnick (*US Dep. Comm. Rep.*, 1957, Dec., 1–9). Moulds were formed by dipping a pattern into an alumina slip and coating with grit to build the desired wall thickness. The green moulds were dewaxed and fired at 2 200°F for 25 min. Castings of 1020, 1030, and 4340 alloy steels were produced for evaluation purposes. Castings had good surface finish, metal quality, and dimensional reproducibility. Short-time moderate temp. firing cycles developed adequate strength in the finished mould. The process appears economically competitive with existing precision casting methods.—S.H.-S.

A contribution to shell moulding V. Vondrák and L. Kuchař (*Sbornik* (*Ostrava*), 1960, **6,** (8–9), 863–876) [In Czech].

Shell moulding in the USSR L. Kelemen (*Koh. Lapok-Öntöde*, 1961, **12,** March, 63–72) The preparation of resin-coated sands, the machines applied in shell moulding and core-making, and the regeneration of used sands in the USSR are described with particular reference to the shell-moulding plant of the motorcycle works at Kiev.—P.K.

Phenolic resins in shell process B. J. W. Simpson (*Castings*, 1960, **6,** Nov., 19, 21).

Shell cores and sand coating A. W. Ulmer (*Castings*, 1960, **6,** Nov., 9, 11, 13, 15, 17, 19) A general discussion with examples.—C.V.

Considerations on the use of plastic moulds in foundries. IV D. Iturrioz (*Met. Elect.*, 1961, **25,** May, 127–129, 131–135) A review of the use of plastic moulds in the Evinrude Motors foundry at Milwaukee, with data on the details of operation throughout the various phases of production, and a closing reference to the use of plastic moulds at the new Holbrook Steel Works of Samuel Osborn & Co. Ltd, Sheffield.

On the contribution of padding to the sound area of the castings M. Sugiyama and T. Fukusako (*Imono*, 1960, **32,** Sept., 642–648) Steel and non-ferrous metals were used.

Some difficulties encountered in moulding heavy steel castings in bentonite mixtures V. Lupač and V. Kyba (*Slévárenství*, 1961, **9,** (5), 186–188) [In Czech] The most frequent types of defects in large castings cast into green bentonite moulds are discussed, and methods of preventing them are considered. The use of coatings made from magnesite or chrome–magnesite powder, with bentonite and dextrin is recommended in parts of the mould particularly exposed to thermal exposure or fluid attrition.—P.F.

Study of the surface of castings K. Katori (*Rep. Gov. Mech. Lab.*, (9), 1952, pp.82) [In Japanese].

Shrinkage defects in iron castings J. H. Gittus (*Iron Steel*, 1960, **33,** Nov., 552–555; Dec., 584–586).

On the fine sand marks with a cloudy appearance in roller-bearing steel SUJ3 K. Deguchi and Y. Matsumoto (*Tetsu to Hagane*, 1960, **46,** Dec., 1751–1757).

Removing sand scabs from castings M. Mareš (*Slévárenství*, 1961, **9,** (4), 154) [In Czech] Methods used in the Šmeral foundry in Brno for the prevention and removal of sand inclusions are discussed with special reference to the incidence of such blemishes on using chemically hardened green moulds.—P.F.

Causes of formation and methods of removal of deep scabs on steel castings L. Rotter (*Slévárenství*, 1961, **9,** (5), 175–178) [In Czech].

Noise: the potential hazard and hearing conservation. H. R. Weston (*Castings*, 1961, **7,** April, 35–45; May, 19–29).

VACUUM METALLURGY

Vacuum treatment of Armco iron in the ladle N. P. Zhetvin (*Stal'*, 1961, (6), 522) A note from 'Serp i Molot'. Vacuum treatment of rimming steel at 3–300 mm for 1–10 min was generally unsuccessful. Killed steel at 20–40 mm for 3–7 min reduced O content (and inclusions) but not C, Mn, Si, or P. Ladle deoxidized metal did better. Armco iron also showed no improvement.

Vacuum degassing of molten steel K. Sanbongi and Y. Omori (*Vacuum Chemistry*, 1960, **8,** July, 115–122; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 547) [No abstract].—C.F.C.

Experiments on vacuum degassing of steels L. Szöke (*Koh. Lapok*, 1961, **94,** March, 135–140; April, 151–156) At 'Csepel' Steelworks in Hungary, various rimming and killed steels were up-hill and down-hill teemed into ingot moulds, or poured from one ladle into another in a vacuum chamber at a pressure between 20 and 40 mm. The steels were made in a basic lined arc-furnace of 8 t capacity. The 0·7–3·6 t ingots showed many radial and some axial inhomogeneities.—P.K.

The D–H (degassing and alloying) process W. L. Finlay and C. D. Preusch (*AISI preprint*, 1961, pp.31) In the DH process, atmospheric pressure forces molten steel from a ladle into a vacuum vessel above, in which degassing and alloy addition takes place. Vertical reciprocating motion of the vacuum vessel forces the molten steel back into the ladle, and provides efficient turbulent mixing. Very low gas contents can be obtained.—A.W.D.H.

Vacuum degassing casting and its equipment R. Fujitaka and M. Yamazoe (*Vacuum Chemistry*, 1960, **8,** July, 107–111; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 547) [No abstract].—C.F.C.

The recent status of vacuum melting and degassing in the steel industry M. Hasegawa and S. Fujinaga (*Vacuum Chemistry*, 1960, **8,** July, 123–129; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 547) [No abstract].

Influence of vacuum-melting on the structure and tensile strength of cast iron M. Kikuchi (*Engng. Pap. Graduate School Sci. Engng. Waseda Univ.*, 1960, No.9, Sept., 43–90; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 588) [No abstract].—C.F.C.

The effect of the crucible on the steel during vacuum melting A. Adachi and K. Mizukawa (*Vacuum Chemistry*, 1960, **8,** July, 102–106; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 587) This investigation was performed to obtain fundamental knowledge of vacuum-melting practice. Low-carbon steel was melted and held in vacuum in alumina, magnesia, and zirconia crucibles for 5 to 120 min and the change of contents of various elements were plotted against the holding time. The reaction between liquid steel and the crucible in vacuum was also considered.—C.F.C.

An investigation of the influence of the different methods of remelting electrochemical steel of Armco iron type on its vacuum tightness N. P. Zhetvin (*Stal'*, 1961, (6), 570) A note from 'Serp i Molot'. Inclusions are much reduced and hairlines and microcracks are removed by vacuum melting. Impurities, especially gases, are much reduced.

Automatic control of vacuum tempering furnace H. Nakagawa (*J. Vacuum Soc. Japan*, 1960, **3,** Dec., 464–470; from *Japan Sci. Res. Mech. Elect. Eng.*, 1961, **7,** Feb., 550) [No abstract].—C.F.C.

Composition change of iron-base binary alloys by vaporization in vacuum melting M. Kawahata, K. Yokota, Y. Sato, and T

Watanabe (*Tetsu to Hagane*, 1960, **46**, Sept., 1423–1425) Aspects illustrated include the change in the amounts of Ni, Co, and Mo and the contents of Mn, Cu, and Cr with time.

REHEATING FURNACES AND SOAKING PITS

Automation of recuperative soaking pits I. N. El'ke (*Stal'*, 1961, (6), 566) A note from Chelyabinsk. Speeding up of heating by 15% and a fuel reduction of 12% are claimed.

Mains-frequency induction heating of ingots for hot-working Y. Putz (*Electrowärme*, 1960, **18**, Dec., 374–379) The installation and method previously used for ingots are applied to drawn and rolled bar. The economy of the process is pointed out and compared with radiation furnaces. Furnace construction for single or multi-coils is described, also the use of several plants in series or vertical coil operation.—E.P.

Flow and pressure conditions in the pusher furnace. Part I. Thermo-pusher furnaces of the Helweg type O. Pauling (*Arch. Eisenh.*, 1961, **32**, May, 315–322) [In German] This part describes the furnace, gives details of the method of circulation, and suggests improvements. **Part II. Investigations into models of pusher furnaces** H. Boenecke. Recent developments into the design of pusher furnaces and experiments with models are described. **Part III.** T. Narjes. This describes the behaviour of pressure in a pusher furnace.

HEAT-TREATMENT AND HEAT-TREATMENT FURNACES

Observations made in the USA on the organisation of jobbing heat treatment shops O. Dorigo (*Tratt. Term.*, 1960, **3**, Nov.–Dec., 27–35) [In Italian].

Flames and furnaces: speed of combustion of solid fuel beds M. W. Thring (*Iron Steel*, 1960, **33**, July, 383–389) An extract from the revised Chapter 3 of the forthcoming second edition of Professor Thring's book 'The Science of Flames and Furnaces' is presented. (Sept., 463–467) The combustion of pulverized fuel is discussed with examples of its use. (Nov., 542–546) The combustion of liquid fuel is examined, and some combustion systems are discussed. (Dec., 596–601) In this concluding section, the combustion of liquid fuels is discussed, with reference to the pressure jet with subsequent secondary air nozzles, calculation of the relation between combustion intensities and pressure, and the combustion of liquid fuel droplets. The ideal conditions for oil-firing are examined (190 refs).

Radiation heat exchange in the reverberatory furnace Jen Shih-cheng (*Acta Met. Sin.*, 1958, **3**, (4), 290–299; from *Sci. Techn. Sci.*, 1959, (2), 73) The formula for heat exchange is derived and compared with another previously advanced.

Experiments on the thermal radiation of flame C. Codegone (**Atti della Academia delle Scienze di Torino*, 1954–55, **89**, 345–349) Results are reported of experiments made on a burner for an aircraft jet engine, from which it appears that the relation between the thermal radiation of flame described in a previous note is approximately verified.

Oil-fired furnaces J. A. Taylor (*Met. Ind.*, 1961, **98**, March 3, 163–166).

Large heat-treatment furnaces (*Iron Steel*, 1961, **34**, May 19, 208–209) A new type Mathison portable cover, clean gas fired, heat-treatment furnace installed at the Coatbridge roll foundry of R. B. Tennant Ltd, suitable for heavy steelworks practice, is briefly described.

'On-the-line' operation with silicon carbide elements Carborundum Co. (*Advanced Mat. Techn.*, 1960, **3**, Jan., 4–5) A heating element made of self-bonded silicon carbide which has the property of increasing in resistance at a slow uniform rate throughout its useful life is described. By means of this furnaces can be operated across the line without using costly transformers. The element and a cross-section of a furnace with the element *in situ* are shown and various examples of operating conditions in metallurgical and ceramic fields are given.

Establishment of accurate conditions for heat treatment in the precision mill following changeover of the furnaces to gas P. Zhetvin (*Stal'*, 1961, (6), 559) A note from 'Serp i Molot'. Difficulties met with are noted.

Electronic installation for programmed control of the thermal régime within thermal treatment furnaces. I B. Popa, A. Simon, S. Kovacs, I. Lazar, C. Boanca, and A. Chirila (*Inst. Politeh. Cluj. Lucrari Stiint*, 1960, 289–296) An electronic installation has been developed for programmed automatic regulation of the thermal régime within methane-fired furnaces for annealing and other heat-treatments. By comparison of thermocouple potentials at the control point in the furnace and at the corresponding programming point, a servomechanism controlled electronically governs the methane flow rate.—M.L.

Electronic installation for automatic regulation of temperatures in heat treatment furnaces A. Simon, St. Kovacs, and I. Helgiu (*Inst. Politch. Cluj. Lucrari Stiint*, 1960, 337–341) An electronic installation for automatic control of the constant final temp. in heat-treatment furnaces has been developed which does not use any moving parts with the exception of an ordinary relay. All problems of translation at the slow and small continuous potential differences of the thermocouples as well as the regulation processes are resolved by electronic means only, with no delays and continuously, with high precision and sensitivity.

Heat treatment and properties of iron and steel T. G. Digges and S. J. Rosenberg (*NBS Monograph* 18, 1960, Oct. 3, pp.40).

Heat processing stainless steel B. A. Reudiger (*Met. Treatment*, 1961, **28**, March, 105–107).

Heat treatment of cast stainless steels. I W. P. James (*Prec. Met. Mold.*, 1960, **18**, Dec., 36, 38).

New furnace heat treats stainless steel for the B–70's C. Lambesis (*Met. Treating*, 1961, **12**, April–May, 15, 32) Brief description of a gantry furnace recently placed in operation at North American Aviation and believed to be the largest and most modern used for heat-treating heat-resisting stainless steel. Together with the draw furnace, it is 60 ft high, 8 ft in dia. It is electrically heated and can heat a 10 000 lb load to 2 050°F within ±10°F.

Effect of carbide stringers on the distortion of die steels during heat treatment K. Sachs (*Met. Treatment*, 1961, **28**, Feb., 59–62; March, 115–119; April, 157–164) In the first part the author compares vertical and horizontal quenching techniques and their effect on distortion. A furnace is then described which imposes a linear temp. gradient on test specimens. The distortion produced by quenching from such a temp. gradient is studied and it is concluded that the distortion is due to γ–α transformation. The effect of specimen shape and size or distortion upon martempering is described, in the second part, and the effect of homogenizing anneal is also discussed. The author deals in the last part with the effect on distortion of different forging methods, heavier deformation in forging and cast structures. He concludes with a discussion of possible practical measures for minimizing distortion.—A.H.M.

Spheroidizing in ball-bearing steel due to isothermal transformation E. Miyoshi and K. Kawano (*Tetsu to Hagane*, 1960, **46**, Sept., 1376–1377).

Effect of heating rate in heat treatment on steel sheets for galvanizing. (Effect of heating rate in heat treatment. III) S. Sakui and T. Mori (*Tetsu to Hagane*, 1960, **46**, Dec., 1740–1744).

Nickel bearing steels treated at temperatures above and below the higher critical point G. Mayer (*Tratt. Term. Met.*, 1960, **3**, Nov.–Dec., 3–18) [In Italian] An examination is reported of the effect of hardening temp. on the mechanical properties of various case-hardened Ni-bearing steels. Data are presented which will facilitate the choice of heat-treatment conditions which ensure the best core and case-hardened layer conditions. In addition, the effect is described of heat-treatment at temp. between the critical points As, and Ac_3 on low-temp. properties of 9%Ni low-C steels.

Heat treatment of welded joints between runs of high tensile steels H. Tauscher and H. Buchholz (*Schweissen Schneiden*, 1961, **13**, June, 230–233) [In German].

Hot extruded ball bearing steel M. Ueno and S. Ikeda (*Tetsu to Hagane*, 1960, **46**, Sept., 1377–1379) After giving the working and heat-treatment history of the specimens, their bending stress and microhardness are illustrated and histograms of the logarithm of cycle to flaking are given.

Evaluation of the effect of mechanical working and heat-treatment on the watt losses in the cores of fractional HP electric motors J. Pustola (**Przeglad Elektrotechn.*, 1959, Oct. 21, 541–549).

The relation between the appearance of fractures and the heat treatment of steels for castings A. Lorene (*Slévárenství*, 1961, **9**, (4), 132–138) [In Czech] Detailed fractographic studies were made of the Ni–Cr–Mo steel 30ChN3MA, and of a 12%Mn steel subjected to various heat-treatments. The relation between the characteristic features of the fracture surfaces and the heat-treatments giving rise to them are discussed.—P.F.

Effect of heat treatment on 18–12 stainless steel containing zirconium T. Adachi, M. Tokizane, and T. Mori (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1002–1404).

Effect of heat treatment on creep-rupture strength of 12% chromium heat-resisting steels T. Fujita and T. Sasakura (*Tetsu to Hagane*, 1960, **46**, Sept., 1390–1393).

On the anneal hardening and deformation temperature of a 304L type stainless steel Y. Hosoi (*Tetsu to Hagane*, 1960, **46**, Sept., 1401–1402) The effect of rolling temp. and the variation of hardness with different annealing temp. after deformation at various temp. are illustrated by graphs. The increased percentage in yield and tensile strength due to annealing at 450°C after deformation is shown.

Relation between hardenability and solution of carbide of high carbon low alloy steels M. Nishihara, T. Nakano, S. Kita, and M. Makoika (*Tetsu to Hagane*, 1960, **46**, Sept., 1425–1426) Jominy hardenability curves are shown. Other aspects dealt with include the relation between the austenitizing condition and the carbon content in austenite and the quenched cooling velocity in relation to quenched hardness.

Precipitation hardening of low-carbon steel M. Klesnil and R. Ryš (*Met. Treatment*, 1961, **28**, Feb., 63–73, 76) Structural changes of a supersaturated solution of α-iron in heat-treating experiments with a low carbon steel. It is concluded that the maximum in the hardness curve coincided with the pre-precipitation state and that a stable structure is produced by cold work and by hardening at two different temp.—A.H.M.

Study on anneal hardening of carbon steel K. Nishino (*Bull. Yamagata Univ.*, 1960, **6**, March, 249–274; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 590) [No abstract].

Carbon control during high temperature carburizing R. W. Krogh (*Met. Treating*, 1961, **12**, April–May, 10, 11, 23, 32) The author indicates the importance of dew-point and atmosphere in certain high temp. carburizing applications. Carbon dew-point temp. relationships are discussed and the author outlines his experiences indicating the advantages of dew-point monitoring at the generator.—A.H.M.

Structure of carburized and carbo-nitrided cases S. R. Rouze and W. L. Grube (*Met. Prog.*, 1960, **78**, Dec., 86–90) Electron microscopical investigations showing the existence of three types of surface conditions—normal, overcarburized, and decarburized—are described, and the characteristics of each type explained.

Supplement for the investigation of high frequency induction surface-hardening of low carbon steel. II. H. Nishimura and K. Kitanaka (*Suiyokwai-Shi*, 1960, **14**, Dec., 220–223) Specimens of 0·05%C steel were quenched from 730°C and aged at 0°, 25°, 36°, 50°, 63°, and 75°C, and their hardnesses were measured. From the results the age-hardening of α-iron was observed. The phenomena of age-hardening are discussed.—C.F.C.

Fundamental study of high frequency surface hardening. 17. On the fatigue strength of surface hardened special steels S. Ishida and Y. Sakai (*Rep. Tokyo Metropol. Ind. Res. Inst.*, 1960, Sept., 34–39; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 551) [No abstract].

Rapid nitriding of steels on heating by high-frequency currents V. I. Prosvirin and B. Ya. Tarasov (*Izvest. AN Otdel. Tekhn. Met. i Toplivo*, 1961, (2), 132–140) The possibility is shown of achieving rapid nitriding in the heating process by high-frequency currents with quenching. High N_2 concentrations and a considerable depth of diffused layer can be obtained for a time of from a few sec to 1–2 min. Nitrogen phases which form are described (23 refs).—A.I.P.

Modified nitriding gives an improved die surface H. K. Barton (*Prec. Met. Mold.*, 1960, **18,** Dec., 31–33) The 'Lubric-Case' process is described wherein a soft nitriding, or second tempering, is carried out in a Cassel type salt bath at $\simeq 570°$ and an exceedingly thin case ($<0{\cdot}001$in) is produced. This surface is not very hard but is exceptionally smooth and it is virtually impossible to produce galling, far less seizure.

Does silicon accelerate decarburization? P. Payson (*Met. Prog.*, 1960, **78,** Dec., 78–81) In the work described, the author found no effect of Si on the decarburization of medium-C alloy steels. The Si is shown to promote separation of ferrite from austenite on cooling; the excess ferrite on the surface of steels high in Si is not due to decarburization, and the effect can be negated by addition of elements added to increase hardenability.

Continuous annealing furnace Leyland Motors Ltd (*Iron Steel*, 1960, **33,** Nov., 547).

Annealing of whiteheart malleable iron in iron ores J. C. Wright, W. J. Elder, and J. C. Billington (*JISI*, 1961, **199,** Dec., 333–342) [This issue].

Open coil annealing V. J. Gibbons (*Sheet Metal Ind.*, 1961, **38,** May, 341–348).

Principles and practices for making very low carbon steel by open-coil-annealing D. J. Blickwede (*AISI Preprint*, 1961, pp.29) The decarburization-annealing of steel coils to make porcelain enamelling sheet is described from the theoretical and practical viewpoints. The main items discussed are the practices for open and tight winding of coils, the gases used for decarburizing, and the major problems of the process.—C.F.C.

Continuous cycle heating–cooling furnace provides better structure control in annealing for machining A. G. Sturrock (*Wire Wire Prod.*, 1960, **35,** March, 340–342).

Computerized control of a continuous annealing line R. H. Smith (*Blast Furn., Steel Plant*, 1961, **49,** June, 529–535).

On the annealing effect in commercial silicon steel sheets K. Haga and H. Mizuno (*Sci. Pap. Inst. Phys. Chem. Res.*, 1960, **54,** Sept., 285–294) [In English] The magnetic properties of sheets containing $\sim 4{\cdot}5\%$Si are improved by annealing in H_2 with increase of annealing temp. For annealing in air, the permeability at low fields is notably increased for high-grade sheets only at temp. of 700–850°C (13 refs).

Magnetic annealing C. D. Graham, jun. (*ASM STP*, 1959, 288–320) A review is presented which is claimed to be concerned only with heat-treatment in an applied field, and, after a survey of general considerations, it examines the annealing of solid-solution alloys, and then proceeds to consider theories of magnetic annealing, the stress-magnetostriction theory, the ordering theory, and the directional-order theory, which last is claimed to explain the constricted or Perminvar loop which regularly appears in materials which respond to magnetic annealing. The precipitation alloys, ferrites, the magnetic properties of thin films, and low-temperature magnetic annealing are also discussed.—S.H.-S.

How to increase the rate of patenting Z. Steininger (*Hutnik*, 1961, **28,** (3), 85–91) The bottleneck being the time of retention in the lead bath, any steel requiring more than 30 sec is unsuitable for needle wire-drawing. To estimate it, the beginning and the end of isothermal decomposition of austenite is plotted against time and temp. and these two curves show whether the decomposition takes place at 450–550°C in less than 30 sec. If it does not, the wire has to be annealed or heated electrically by resistance or induction.

Development of the technology of continuous patenting and etching of wire on a thermal-etching assembly N. P. Zhetvin (*Stal'*, 1961, (6), 559) A note from 'Serp i Molot'. Various changes in the line are mentioned.

Change in brightness of bright quenched steel parts, due to deterioration of quenching oil by thermal decomposition M. Tagara, I. Tamura, and M. Tanaka (*J. Metal Finish. Soc. Japan*, 1960, **11,** Nov., 629–632; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 551) [No abstract].—C.F.C.

The oleodynamic method for rationalizing quenching (*Trattamenti Term. Met.*, 1960, **3,** Nov.–Dec., 36–42) [In Italian] The technological principles on which the oleodynamic method is based are described with the aid of diagrams and illustrations.

Study on austempering of 9%W–Cr–V series spring materials H. Hotta (*Tetsu to Hagane*, 1960, **46,** Sept., 1374–1376).

Automatic hardening and tempering of carbide barrel forgings GWB Furnaces Ltd (*Iron Steel*, 1960, **33,** Dec., 576–577, 581).

The effect of prestraining and retempering on AISI Type 4340 E. T. Stephenson and M. Cohen (*Trans. ASM Quart.*, 1961, **54,** March, 72–83) This investigation comprises an attempt to improve the strength of AISI 4340 by a combination of thermal-mechanical treatments consisting of hardening, tempering, straining, and retempering. Straining increases strength and decrease ductility, with return of a yield point. As retempering temp. is raised, these effects are enhanced until a maximum in strength and a minimum in ductility are reached, when yield-tensile strength ratio becomes unity and stable elongation (plastic elongation to the maximum load) drops to zero, even though the total elongation is still appreciable. The electron micrographs indicate that the carbides in the tempered martensite are dissolved and reprecipitated by the straining and retempering. The accompanying yield point phenomena are attributed to effecting locking of dislocations by a redistribution of the carbon and/or carbides.

FORGING, STAMPING, DRAWING AND PRESSING

Investigation of vibro-insulation of the foundations of drop hammers under production conditions V. F. Shcheglov and V. V. Kurin (**Kuznechno-Stampov*, 1960, (9), 21–26).

Vibro-insulation of drop hammers at the Taganrog Combine Works G. I. Bezzubyi (**Kuznechno-Stampov*, 1960, (9), 26–31).

Forges de la Providence at Haumont (*Aciers Fins Spéc.*, 1960, Dec., 36, 101–103).

Precision forging. The formation of rifling in small arms barrels by a precision forging process L. R. Beesly (*Machinery*, 1960, **97,** Nov. 16, 1145–1148).

Forging research in Sweden E. Tholander (*Met. Treatment*, 1961, **28,** March, 89–94) The author describes the forging laboratory at Eskilstuna and details some of the researches carried out there. These include tests on lead with plain tools and with closed dies. A study is briefly reported of the scaling and decarburization of heated steel.—A.H.M.

Precision forging of steel shafts R. Speck (*Met. Treatment*, 1961, **28,** March, 95–98).

Effect of streak flow on forging and heat treatment Y. Yasuda, K. Fujii, S. Otsuki, and H. Hirata (*Tetsu to Hagane*, 1960, **46,** Sept., 1356–1357) Details of samples used are given and the conditions of quenching and hardness are tabulated.

New machinery and equipment for cold forging of steel H. D. Feldmann (*Wire*, 1960, (48), Aug., 132–135).

A research study on the hot deformation of steel C. Rossard and P. Blain (*Obra. Plas.*, 1960, **2,** (1), 7–58) The authors are concerned with the behaviour of specimens both under torsion and tension and considering such factors as stress, strain, strain rate, temp. and the mode of deformation. It was found that for a given deformation the stress remained constant, independent of deformation. This would occur following initial oscillations. An equation could be evolved connecting stress t and speed of deformation (dg/dt) independent of deformation, in the form: $t = t_0\ (dg/dt)^n$, n being a coefficient expressing sensitivity to deformation speed. Crystallographic examination showed the crystal sizes and configurations to be related to the various states, i.e. the oscillatory and steady states as well as the speed of deformation.

The effect of temperature and deformation rate on the flow resistance of steel in forging operations V. Valorinta (*Obr. Plas.*, 1960, **2,** (1), 59–71) The author points out that as deformation proceeds, the metal structure will contain work-hardened as well as recrystallized stress relieved grains. Consequently the flow resistance depends on the relative proportions of the two groups. This in turn depends on the forging method and temp. As a result of tests carried out the author has evolved equations relating flow resistance to deformation rate and temp. Furthermore the author observes that the flow resistance of alloy steel depends on the effect of the alloying elements on the structure rather than on the amount of these elements.

Fabrication aids tomorrow's sheets M. F. Garwood (*SAE J.*, 1960, **68,** Sept., 59, 60) The author briefly reviews recent advances in cold forming in steel and predicts that this process will replace many hot forging and machining operations. Cold extrusion of steel is given as an important example. Two new heat-treatment processes are also described. These are carbonitriding and suspended carburization.

The use of phosphating in the cold heading of fastener elements F. M. Ladyzhenskaya, O. A. Ryabchikova, L. I. Fudim, V. A. Chetvertkova, and L. Ya. Lapshin (*Stal'*, 1961, (5), 471–474).

Production procedures at the Beacon works of John Thompson Motor Pressings Ltd (*Sheet Metal Ind.*, 1961, **38,** March, 162–170; May, 320–329).

Forming of metal sheet and blank material G. Chauvelin (*Europ. Masch. Markt.*, 1960, **10,** (11), 25–27) The design of blanking and forming tools from densified wood and metal is discussed. Using this material, working is similar to that with other blanking tools although the arrangement of the tool is inverted; the blanking stroke must be rather short and the penetration of punches into the die must be reduced to a min. (0·3–0·5 mm) but with this limitation it can be used on mechanical, hydraulic, or even screw percussion presses. Densified woods have a degree of self-lubrication; with stainless steel and duralumin a tallow-castor oil mixture is suitable.—C.V.

Effects of hot–cold working on high speed steels R. F. Harvey (*Cobalt*, 1961, **11,** June, 36–37) The hot pressing of M–2 and M–6 high-speed steels results in deformation which occurs in the metastable austenitic condition. This results in work hardening and less austenite being retained in the martensite matrix. In consequence the Rockwell hardness, at room temp., is about 2 points higher than those for the air-cooled steels.—A.W.D.H.

Sheet-metal stamping and pressing W. G. Cass (*Sheet Metal Ind.*, 1960, **37,** 671–674) The article summarizes recent researches in the USSR.

Sheet metal data sheet—9. Press-tool nomenclature J. W. Langton (*Sheet Metal Ind.*, 1960, **37,** Sept., 691–692).

Development of high-speed hot transfer presses F. Meyercordt (*Wire*, 1960, (48), 136–140).

Tough ceramic tools can punch through steel Carborundum Co. (*Advanced Mat. Techn.*, 1960, **3,** Jan., 8–9) 'Stupalox' is an Al-oxide material essentially Al_2O_3; it is polycrystalline and is produced by the simultaneous application of heat and pressure to the powder. Its strength and toughness is maintained up to 2000°F and it is self-bonded and contains no vitreous phase; there are no discontinuities or irregularities. Various uses are discussed, single point cutting tools, balls, rollers for bearings, etc. It has a compressive strength of 400000 psi, is non-magnetic, and although it possesses a high thermal conductivity, this is much lower than other metallic cutting tools. Chemically it is unattacked by most acids, gases, and alkaline solutions, and oxidizing and reducing atmospheres have no appreciable effect. Various shapes and sizes can be obtained by diamond grinding and fabrication with epoxy resins is considered.

Blanking and forming can lids and drum ends J. Waller (*Austr. Mach. Prod. Eng.*, 1960, **13**, Dec., 29–31).

Cold squeezing square shanks M. Olszewski (*Obr. Plas.*, 1960, **2**, (1), 127–136)

A classification of defects in press worked parts B. Kwasniewski (*Obr. Plas.*, 1960, **2**, (1), 87–105) The author evolves a system of letter and number combinations for describing defects. The letter would describe type, e.g. forged, extruded, the first digit of the number would describe a general grouping, e.g. dimensional error, surface fault, the second digit a sub-division of this group, e.g. uneven thickness, flaking, and so on. A similar notation is applied to the causes of the various faults.

Material stressing and work required in right-angled cold bending of sheet in presses, bending-off machines, and sectioning machines H. Mäkelt (**Industrie-Anzeiger*, 1960, March 29, (26), 17–24, 383–390) Investigations carried out in collaboration with the Forschungsgesellschaft Blechverarbeitung on problems in sheet bending gave rise to the following ideas, which suggest ways in which the stressing of the material and the work required in right-angled cold bending can be calculated beforehand for the various bending processes and machines with greater accuracy than was possible with the methods and formulae hitherto in use.—S.H.-S.

Recent developments in explosive forming and welding in the U.S.A. (*Sheet Metal Ind.*, 1960, **37**, Sept., 681–682).

Tools and methods for drawing sheet metal J. Waller (*Mech. World*, 1960, **140**, Dec., 514–519).

Anisotropy as an asset for good drawability R. L. Whiteley, D. E. Wise, and D. J. Blickwede (*Sheet Metal Ind.*, 1961, **38**, May, 349–353) Blanks from various coils of steel sheet were subjected to several pressing operations, and fewer breakages occurred in the steels with the higher strain ratio, though the ductilities were comparable. Thus it was concluded that the strain ratio of the metal, as well as its stretchability, influence its drawability.—A.W.D.H.

The use of an electrical analogue model to determine the temperature in the deformation zone of drawing I. N. Nedovizii, I. M. Gel'fand, and V. F. Al'ter (*Stal'*, 1961, (6), 567–570) The principles of construction of the model are given and the calculations are presented. Rate of increase of temp. is shown to decrease with increased drawing speed.

Perfecting the process of the hot drawing of wire and rods N. P. Zhetvin (*Stal'*, 1961, (6), 559) A note from 'Serp i Molot'. Steel R18 is best heated to 500–600° and drawn at 280–320° or at 460–600° as a fall of ductility is observed at 340–440°.

An investigation of dry and liquid lubricants for drawing rods and wire N. P. Zhetvin (*Stal'*, 1961, (6), 559) A note from 'Serp i Molot' jointly with NEFTEGAZ. Various soaps were used with salts and alkyl sulphates.

A new test method for determination of spinnability of metals R. L. Kegg (*Trans. ASME*, 1961, **83B**, May, 119–124).

The evaluation of sheet for deep drawing R. Pearce (*Sheet Metal Ind.*, 1960, **37**, Sept., 647–652, 660) The author describes the test methods practised by most motor-car-body press shops. He details the tensile test of mild steel and outlines other tests such as hardness, metallographic, and chemical analysis. He then surveys a number of simulative tests and concludes by a discussion of the three basic forming methods used in the press shop, namely, stretching, bending, and drawing.

A method of calculating drawing force for ordinary wire K. Janas (*Hutnik*, 1961, **28**, (3), 107–113) W. Lueg and A. Pomp's formula for calculating drawing force from Brinell hardness is applicable only to bars or very thick wires. In case of the ordinary wire, the measurement of Brinell hardness being impracticable, the drawing force has to be calculated from the tensile strength and degree of reduction.

The modern development of wire rope D. van de Moortel (*Wire*, 1960, Aug., 127–131; Oct., 189–193).

The fundamentals of wire drawing. 5. Calculating drafts C. P. Bernfoeft (*Wire Ind.*, 1960, **27**, Nov., 1103, 1125) A brief mathematical presentation of examples, statistics, and formulae.—S.H.-S.

Study on martensitic stainless spring steel wires. I (*Denki-Seiko*, 1960, **31**, May, 130–143) [In Japanese] [No Summary].—J.E.J.

Stiffness factor: a quality control measurement for wire N. W. Roberts (*Wire Wire Prod.*, 1960, **35**, March, 350–351).

Quality control in the wire industry E. F. Jubb (*Wire Ind.*, 1960, **27**, Nov., 1105–1107) Wire-drawing, annealing, galvanizing, etc., statistical quality control, and practical operation are briefly reviewed.—S.H.-S.

An experimental investigation into the cold extrusion of steel H. L. D. Pugh, M. T. Watkins, and J. McKenzie (*Sheet Metal Ind.*, 1961, **38**, April, 253–283) The authors report studies of the extrusion pressure, metal flow during deformation, and the mechanical properties of the extruded component. Process parameters studied include tool geometry, lubrication, ram speed, steel composition, slug geometry, and slug preparation. Limitations of the process are revealed by the results of their investigations; they include material flow and tool overstressing.—A.H.M.

Cold and hot precision extrusion of metals R. A. Quadt (*Obr. Plas.*, 1960, **2**, (1), 107–125) The author reviews the progress in precision extrusion development pointing out that specialized techniques allow the production of complex shapes from the more difficult metals such as hard Al alloys, steels, etc.

Cold extrusion of small symmetrical and asymmetrical components O. May (*Sheet Metal Ind.*, 1961, **38**, May, 335–340) The punching of small components from steel strip is discussed. It is demonstrated that the best results in cold extrusion processes are obtained when the parts are degreased, and that the metal should be allowed to flow more slowly than is possible with an eccentric press.—A.W.D.H.

Tool materials for the cold-extrusion process A. W. F. Comley (*Sheet Metal Ind.*, 1961, **38**, March, 190–207) The selection of tool materials in the light of already published data from sources throughout the world is considered, details of defects to be found in tool steels are discussed, and recommendations made for heat-treatment practice, with a suggestion that for punch and die work Mo high-speed steel would be a suitable material for the punch and carbide for the die.—S.H.-S.

Phosphate coating and lubricating steel for cold extrusion D. James (*Sheet Metal Ind.*, 1961, **38**, March, 171–189, 207).

ROLLING MILL PRACTICE

The contribution of the steelworks to the increase of yield in rolling mills O. Bohuš (*Hutník*, 1961, **11**, (5), 211–217) [In Czech] The paper and the appended discussion deal with the effect of steelworks production technology on the quality and dimensions of ingots, and the bearing of these variables on the rational utilization of metal in the rolling mill.

Study for the preparation of work in the mechanical department of a rolling mill J. J. Fernandez Fernandez (*Met. Electr.*, 1960, **24**, Oct., 92–104) A study of rationalization in the tooling section of the department with 10 figs. and comparative data on Belgian, French, American, and German equipment for five classes of materials and alloys.—S.H.-S.

Theory and practice of flat rolling C. W. Starling (*Sheet Metal Ind.*, 1960, **37**, Sept., 683–689, 690).

An introduction to the theory and practice of flat rolling. 7 C. W. Starling (*Sheet Metal Ind.*, 1961, **38**, March, 211–218) A chapter of the author's textbook, dealing with measurement of rolling load and torque, presents methods of measuring load, followed by details of various mechanical, hydraulic, and electrical load meters. Similarly, after considering methods of measuring torque, details are given of mechanical and electrical systems which can be used for torque measurement. **8** (April, 247–252) In this contribution the author deals exclusively with the planetary mill. A description of the mill is given together with the mechanics of the rolling operation. Merits and uses of the mill are discussed, in particular the possibility of it replacing several stands in a continuous rolling line.

Filming the internal movement of metal in the deformation zone during the metal rolling process O. G. Muzalevskii (**Zhur. nauch. i prikladn. fotografii i kinematografii*, 1958, **3**, (5), Sept.–Oct., 363–367) A new method applying the principle of 'combination filming' is presented to show the metal deformation in rolling by filming the deformations of a co-ordinate grid superimposed on the side surfaces of rolled specimens, making it possible to show metal flow at the sides of a strip. Internal areas were, however inaccessible to this method. Special specimens with holes for filming transmitted light, instead of reflected light, were made for investigating the deformation process inside a strip, and were passed in front of a special transparent matt screen, illuminated by transmitted light from spotlights. The process and conclusions to be derived thereform are described.—S.H.S.

The attenuation of dimensional variations in rolling J. F. Wallace and K. Bayley (*Sheet Metal Ind.*, 1961, **38**, April, 242–246) The paper indicates lines of development of reactive and resistive methods for attenuating and controlling variation in gauge and profile of rolled sheet. The prestressing technique is outlined and it is shown that it is applicable to continuous bar mills with short rolls.

Shapes of sticking areas of metal during the process of rolling Soong Rei-yu (*Acta Met. Sin.*, 1958, **3**, (4), 306–313; from *Sci. Abs. China Techn. Sci.*, 1959, (2), 72).

Calculation of the contact surface in rolling, taking into account the elastic deformation A. I. Tselikov (*Stal'*, 1961, (6), 526–527).

Applications of rectifiers to rolling mills M. Mattá (**Bull. Sci. de l'Assoc' Ing. Electr., sortis de l'Inst. Electrotech. Montefiore* (*Bull. AIM*), 1959, April–May, (4–5), 323–342) The Brown-Bovery grid method of voltage regulation and wave-form operation in a hot rolling mill is described, with the principal circuits recommended based on 40 years' experience on continuous mills and is followed by a description of their use in reversing mills after 20 years' experience with the latter. The average reactive power with the use of rectifiers determined for the full control range from 0 to 100% is presented.—S.H.-S.

S.G. iron rolls A. Šprencl (*Hutník*, 1961, **11**, (5), 219–223) [In Czech] S.G. iron rolls produced in Czechoslovakia are classified, and the performance of some in practice is discussed. Such rolls are suitable for most rolling purposes and are cheaper than steel ones. Probable future development in the production and use of S.G. iron rolls are considered.—P.F.

Rectangular roll pass design for rolling carbon and alloy steels S. G. Nekrasov (*Stal'*, 1961, (6), 541–542) Factors taken into account in design are discussed.

New steels for building up the rolls of continuous intermediate and of blooming mills by automatic electrowelding M. M. Finkel'shtein (*Stal'*, 1961, (6), 535–538) Instead of PP 3Kh2V8 powder wire the cheaper 5Kl4V3F and 4Kh2G2V wires have proved more effective, giving rolls with longer life.

Transient thermal stresses in hollow cylinders by rapid heating with special application to the heat condition of a hot roll I. Nakahara (*Trans. Japan Soc. Mech. Engrs.*, 1960, **26**, Oct., 1395–1403; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 472) Cracking of a steam-heated roll was studied. Rates of safe heating for rolls closed at the ends can be calculated.

Centralized lubrication for 32in billet mill A. E. Annable (*Iron Steel*, 1961, **34**, May, 166–171).

Two high slabbing mills for Fuji Iron and Steel Co. Ltd S. Haraguchi, H. Ishii, and K. Fukui (*Hitachi Hyoron*, 1960, **42**, Oct., 1041–1045; from *Japan Sci. Rev. Mech. Electr. Eng.*, 1961, **7**, Feb., 550) [No abstract].—C.F.C.

Study on a precision rolling mill H. Suzuki and S. Hashizume (*Seimitu Kikai*, 1960, **26**, Oct., 569–579; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 550) A special mill for rolling coelinvar watch springs was studied.

Automatic drive control used in a Swiss continuous merchant and rod mill L. Walter

(*Wire Wire Prod.*, 1961, **36,** May, 606–607, 657–658) The general layout and high-precision wire control in operation at Ludwig von Roll Steelworks AG, Gerlafingen, Switzerland is described, with data on control room, mutator room, drives, and controls of rotating shears, with diagrams of mill arrangement and hook-up.—S.H.-S.

A brief survey of wire rod defects: their occurrence and detection G. Earnshaw (*Wire Wire Prod.*, 1961, **36,** May, 591–592, 594–596, 645–656).

The universal beam and heavy structural mill at the Lackenby works of Dorman Long (Steel) Ltd A. P. Clark and R. E. Kenderdine (*JISI*, 1961, **199,** Dec., 343–360) [This issue].

The design of up-to-date wire and small section rolling mills H. P. Lemm (*Koh. Lapok*, 1961, **94,** March, 101–108; April, 157–164) The main principles in designing up-to-date wire and small section rolling mills are reviewed with special attention to close tolerances. The layout of such mills is also described.—P.K.

Economics of light sections F. E. Fahy (*Blast Furn. Steel Plant*, 1961, **49,** June, 519–524; also *AISI preprint*, 1961, pp.34) By using deeper sections, beams can be made to have the same stiffness, but use less steel than standard sections. These have many advantages, and the steel industry should learn to think of providing a certain number of structural members, rather than a certain quantity of steel.

Stainless spring steel wire and spring steel strip K. Kayser (*Wire*, 1960, (48), Aug., 149–153).

The rolling of parallel flanged beams W. Müllenbach (*Demag Nachr.*, 1961, (162), 1–9) [In German].

Consett developments (*Iron Steel*, 1960, **33,** Dec., 588–594).

Fully automatic sheet grading F. J. Littell Machine Co. (*Iron Steel*, 1960, **33,** Nov., 556–557) In the equipment described, designed, and built by Bren Manufacturing Co. for the American firm, operation is fully automatic, including pallet positioning, hoisting, lowering, and ejection of the loaded pallet.

The automation of roughing reversing mills V. I. Arkhangel'skii, R. V. Lyambakh, and O. V. Spezhanovskii (*Stal'*, 1961, (6), 528–534) The old types of automation devices are less productive than manual control. New systems using computers are now worked out which should lead to complete automation. A system using a computer and pickups and sensing devices is described.

Remarks on the electric installations of sheet rolling mills A. Honců (*Hutnik*, 1961, **11,** (4), 168–173) [In Czech].

The Brinsworth cold-strip mill at Steel, Peech and Tozer branch of United Steel Co. Ltd (*Sheet Metal Ind.*, 1961, **38,** May, 359–366).

Rolling equipment for production of sheet and strip in Czechoslovakia (*Czech Heavy Ind.*, 1961, (5), 4–17).

Improving the production technique of work-hardened strip from 1Kh18N9 steel N. P. Zhetvin (*Stal'*, 1961, (6), 542) A note from 'Serp i Molot'. Ni has the greatest effect on this grade and cannot be above 10% Ti over 0·3% shows an effect, especially with high Ni. Optimum composition appears to be 0·09–0·12%C, 17–18%Cr, 8–9%Ni, and 0·3% Ti. A new grade, Kh17N7, is suggested.

Deformation of metastable austenite and the strength of steel strip V. Ya. Zubov, N. V. Sokolov, L. A. Krasil'nikov, and S. V. Grachev (*Stal'*, 1961, (6), 549–551) Considerable increase in the tensile strength of spring steel strip is attained by flattening. The role of martensite in the process is discussed.

Quality control of sheared strip English Electric Co. Ltd (*Sheet Metal Ind.*, 1961, **38,** May, 356–357).

The production of cold rolled strips of transformer steel F. Balázs and B. Ágotsi (*Koh. Lapok*, 1961, **94,** May, 193–196) The effect of the chemical composition, hot and cold reduction, heat treatment, furnace atmosphere, and other factors on the Goss texture of cold-rolled transformer-steel strips has been examined.

The cold rolled transformer steel 'T 0·8 Special' with preferred orientation S. Shrbený and J. Vaclík (*Hutník*, 1961, **11,** (5), 217–219) [In Czech] The mechanical and magnetic properties of a Czechoslovak transformer steel, essentially similar to materials such as 'Hypersil', 'Hyperm', or 'Trafoperm', are described, and the production technology is discussed.—P.F.

Development of electric drives and control for high-speed tandem cold-reduction mills H. D. Morgan and P. E. Peck (*JISI*, 1961, **199,** Dec., 361–374) [This issue].

Tension control in winding reel drive J. Oyama (*Toshiba Rev.*, 1960, **15,** Dec., 1349–1364; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 549) [No abstract].—C.F.C.

Automatic gauge and tension control (*Iron Steel*, 1961, **34,** May, 176–177) An automatic gauge sampling system, initiating correction by means of pulses, installed at the Ebbw Vale works of Richard Thomas and Baldwins Ltd, which has been in successful operation since March 1960, is briefly described.—S.H.-S.

Developing the technology for the 'warm' rolling of sheet from steels of low ductility N. P. Zhetvin (*Stal'*, 1961, (6), 542) A note from 'Serp i Molot'. Steels with unstable austenite, EI 100, and EI 925 gave the greatest improvement in ductility with this treatment.

Tandem cold rolling Steel Peech & Tozer Ltd (*Iron Steel*, 1961, **34,** May, 178–180).

Push button integrated cold rolling Steel Peech & Tozer Ltd (*Engineering*, 1961, **191,** April 7, 490–491).

Some review of cold rolling by Sendzimir mill T. Ohama and Y. Ueda (*J. Japan Soc. Mech. Engrs.*, 1960, **63,** Nov., 1500–1505; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 550) [No abstract].—C.F.C.

Piercing machine of small diameter seamless tubes (*Iron and Steel*, 1959, (2), 59–63; from *Sci. Abs. China. Techn. Sci.*, 1959, (2), 72) Recommendations on operations are set out.

The calibration of Mannesmann piercing rolls A. Strömpl (*Koh. Lapok*, 1961, **94,** April, 169–176) The piercing methods of several foreign tube-rolling mills are reviewed. The calibration of 6–12in piercing rolls at the 'Csepel' Steelworks in Hungary is described, and the results obtained with these rolls are evaluated.—P.K.

Improving the production techniques for hollow steel for boring bits N. P. Zhetvin (*Stal* 1961, (6), 542) A note from 'Serp i Molot'. Increasing the dia. of the first bore from 27 to 29 mm and the mandrel from 26 to 28 mm gives better cavity shape and higher output.

The distribution of stresses in the surface layers of expanded tubes from 19G steel V. A. Gladkovskii (*Stal'*, 1961, (6), 542) A note from Chelyabinsk. Expansion by 0·9–1·1% greatly reduces residual stresses. The expansion by 1·6% practised in the works does not always remove the residual macrostresses.

Mandrel drawn tubes M. Schneider (*Hutnik*, 1961, **28,** (3), 79–84) A formula and a numerical example is given to calculate the pressure required for elongation and reduction of steel tubes. Out of the total pressure exerted only 40% is required to do the work of deformation, the rest being lost in overcoming friction.

Automatic computer control system for billet cut-up line Samuel Fox & Co. Ltd (*Iron Steel*, 1961, **34,** May 19, 209).

Hydraulic bloom and slab shears A. Hertl (**Techn. Mitt.*, 1958, **51,** Oct., 513–519) The operation of cutting blooms or slabs to divide the material to be rolled into smaller lengths and the rejection of defective material at the beginning of the rolled material as well as the ends which are worthless owing to 'fish-tailings' of lamination is described in detail with 10 figs. and a diagram comparing shearing strength in mild carbon steel and high-alloy steel. The replacement of electro-mechanical drive by hydraulic oil drive, due to advantages of material construction and space requirement, is discussed and predicted.—S.H.-S.

MACHINERY AND SERVICES FOR IRON AND STEEL PLANT

Productivity through industrial maintenance L. N. Misra (*Trans. Indian Inst. Met.*, 1960, **13,** Sept., 277–284).

Power plant developments at the Steel Co. of Wales Ltd (*Iron Steel*, 1960, **33,** July, 378–381).

The weighing of goods wagons, particularly of those in motion on inclined weighbridges E. Massute (**ETR*, *Sonderausgabe*, 11, 1959, Sept., 57–67).

On the planning and costing of railway freight journeys and the wages system for footplate crews E. E. Bermant and M. S. Kuznetsov (*Stal'*, 1961, (6), 563).

Jointless crane rails in the shop of a metallurgical combine N. E. Gorozhaninov and L. I. Zverev (*Stal'*, 1961, (5), 477–478).

WELDING AND FLAME CUTTING

Welding of cast irons and nodular graphite cast steels. 1. Microstructure in arc welding M. Homma, T. Wada, and K. Yamaya (*J. Japan Welding Soc.*, 1960, **29,** Oct., 812–818; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 552) [No abstract].—C.F.C.

Combined welding without preheating of grey cast iron A. Leichtenböhmer (*Metall*, 1960, **14,** Sept., 907–909) The technique of welding with several types of welding rods, without preheating the metal, is described with examples.

Spot welding low-carbon steel sheet (*Sheet Metal Ind.*, 1960, **37,** Sept., 661–666, 670).

Ferritic welding of steel armour Z. J. Fabrykowski (*Weld. J.*, 1961, **40,** April, 339–342) The development of ferritic electrodes and the results of the US Army 'H' plate test are described and tabulated with welding and ballistic results of 1½in 'H' plates, and a brief summary of inspection methods.—S.H.-S.

Technique for welding very thin and thick sections together Ryan Aeronautical Co. (*Machinery*, 1960, **97,** Nov. 16, 1133–1135).

CO_2-shielded arc welding of steel A. A. Smith (*Overseas Eng.*, 1961, **34,** May, 306–309) A process is presented and discussed which is claimed to have many advantages over other methods for many applications, being semi-automatic, fast, and easy to use, and its labour costs about one-third those of manual methods. The steps taken to resolve the problems of porosity in the weld metal, metal transfer causing spatter on the work, and the difficulty of positional welding are explained; the special features of the process are reported and its future prospects and economy of operation are reviewed.—S.H.-S.

Powder welding process Deloro Stellite Ltd (*Auto Eng.*, 1961, **51,** March, 111–112) A new method for manual or mechanized deposition of Stellite heat-resistant corrosion-resistant, and wear-resistant hard facing alloys is described. This is twice as rapid as arc-welding and four times more rapid than gas welding and risk of work distortion is minimized. Spraying and fusing are performed in one operation and the deposit is relatively smooth and needs little finishing.

The welding of austenitic steels H. Krainer (*Schweisstechnik*, 1961, **15,** May, 54–59) The corrosion phenomena and warm cracking related with the welding of a series of austenitic steels listed, are discussed and ways for their prevention are considered.—M.L.

Welding of martensitic steel G. A. Nikolaev and A. V. Mordvintseva (*Obrabotka zharoprochnykh splavov*, Moscow, 1960, 131–137) At the Bauman higher technical institute (MVTU, Moscow), investigations have been carried out into the processes of formation of stresses and deformations during the welding of different types of steel. Many factors were studied and the main results are presented in the form of six graphs and three short tables.—A.I.P.

The welding up of a crack in a casting made from medium-carbon steel A. I. Pashchenko (*Lit. Proizv.*, 1958, (11), 36).

Use of gas welding for repairing cast-iron parts K. P. Voshchanov (*Lit. Proizv.*, 1958, (11), 26–29).

Type UDSSh-4 installation for the arc welding of cotter pins D. I. Vainboim (*Svar. Proizv.*, 1958, (12), 32–33).

Thermite welding O. Milos (*Schweisstechn.*, 1960, **14,** (7), 73–78).

Welding of cast iron and nodular graphite cast steel. I. Properties of the heat affected zone of cast iron. II. Arc welding of nodular graphite cast steel M. Homma, T. Wada, and K. Yamaya (*Sci. Rep. Res. Inst. Tohoku Oniv.*, 1960, **12,** Oct., 437–447; 448–455) [In English] I. The

thickness of the ledeburite layer varies with the m.p. of the electrodes. White and dark martensite, corresponding with fast and slow cooling below M_s, are formed according to the different welding conditions. Diffusion of Ni is small (27 refs). II. The main difference from cast iron is the absence of ledeburite. Tensile and other properties of butt welds are enumerated for various electrodes.—K.E.J.

A solution adopted in some difficult applications of flash welding E. Bylin (*Weld. J.*, 1961, **40,** May, 229s–240s) An investigation on the flash welding of cast iron as employed for joining flanges to centrifugal-cast pipes and as applied to creep and heat-resisting high-chromium nickel alloys with basic analysis of 20%Cr, 0–20%Co, 70–50%Ni, 5%Fe, and 5%Al+Ti+Si, used in jet engines was performed in a machine with automatically controlled motor-operated upsetting, whereby the upsetting speed is considerably lower than that used in hydraulically operated machines. It was proved that flash welding of cast iron is possible if accurate control of upsetting stroke and low specific upsetting pressure are maintained. With creep resisting alloys considerably lower pressure can be used, due in part to the possibility of controlling upset travel exactly, and in part to controlling the current during the upsetting and the possibility of breaking the current at the most suitable moment.

Resistance butt welding of steel wire of high carbon content H. J. Böckenhoff (*Stahl Eisen*, 1961, **81,** March 16, 337–349) The steels used for the wire welding experiments were OH steels with carbon contents ranging from 0·06 to 0·87%. The welding process is described in detail as well as the effects of the welding conditions and the steel composition on the properties of the welds. A process for the production of welds without impoverishing the weld of carbon has been developed. The effect of a heat-treatment of the weld has also been studied as well as that of a deformation. Carbon impoverishment could be reduced by lowering welding time and welding pressure.

Experience in the electro-slag welding of grade 1Kh18N9T steel A. G. Fomin (*Svar. Proizv.*, 1958, (12), 21–23) This steel can be satisfactorily welded by the electroslag method with the application of a lamellar electrode of the same steel. Techniques which ensure good quality seams in the welded joints, have been evolved for blanks 160–230 mm high by 120–200 mm. The welded joint meets technical specifications for gaskets for nitrogen and oxygen regenerators.—A.I.P.

Temperature, material transfer and physical properties of slags of unalloyed welding electrodes W. Hummitzsch (*Schweissen Schnieden*, 1961, **13,** 187–195) A survey, concluding that measurement of the electric conductivity is suitable for determination of structural changes and temp. of slags of unalloyed welding electrodes, while their viscosity is a suitable criterion for determination of their work properties (18 refs).—M.L.

Improvement in the quality and deformability of alloy steels and alloys by means of electroslag remelting in a metal crystallizer B. E. Paton, B. I. Medovar, and Yu. V. Latash (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5,** 228–233) At the Paton Electrowelding Institute a method has been evolved for electroslag remelting in a copper or steel air-cooled crystallizer using spent electrodes for the charge. For improving the quality and technological features of many steels and alloys this method is better than electric arc welding.—A.I.P.

Metallurgical questions of the electroslag welding of heat-resisting austenitic steels and alloys on a nickel–chromium base B. I. Medovar and A. N. Safonnikov (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5,** 220–227) A thorough description of electroslag welding is given in view of the rapid development of atomic power and rocket technology and the consequent necessity to use welding for making manufactured parts, joints, and constructions from heat-resisting austenitic steels and alloys in the form of rolled stock forgings, and castings of great thickness, often, exceeding 100–150 mm.—A.I.P.

Welding of massive manganese–vanadium steel assemblies for Varrazano-Narrows Bridge tower piers I. Diamond (*Weld. J.*, 1961, **40,** April, 359–362).

Welding type 410 stainless steel to inconel J. D. Casey (*KAPL*–2087, 1960, March, pp.8; from *US Res. Rep.*, 1960, Dec. 16, 808) [No abstract].—C.F.C.

The metal arc welding of stainless steels M. C. T. Bystram (*Edgar Allen News*, 1960, **39,** Dec., 273–275).

Ultrasonic welding engineering, manufacturing and quality control problems J. Koziarski (*Weld. J.*, 1961, **40,** April, 349–358) The nature of ultrasonic welding is described and various design and manufacturing problems are discussed. Quality control requirements as compared with conventional resistance welding, and practical qualifications for welding equipment, and of welding schedules are reviewed.

Inert gas tungsten-arc spot-welding for missile assemblies W. P. McGregor (*Machinery*, 1961, **98,** April, 886–888).

Projection welding low carbon steel using embossed projects J. F. Harris and J. J. Riley (*Weld. J.*, 1961, **40,** April, 363–387).

Basic principle of electroslag welding and equipment for the process G. Almquist (*ESABs Tidning Svetsaren*, 1960, **25,** (1), 1–10)

Practical application of electroslag welding B. Kjellberg (*ESABs Tidning Sversaren*, 1960, **25,** (1), 11–24).

Welding cracks in cast iron moulds without reheating N. P. Zhetvin (*Stal'*, 1961, (6), 575) A note from 'Serp i Molot'. The cracks are gouged out and welded with Cu and then with steel electrodes.

The design of welding electrodes I. C. Fitch (*AEI Eng. Rev.*, 1961, **1,** May, 205–210).

Study on electrodes applicable to 19–9 DL heat-resisting steel Y. Ito (*J. Japan Welding Soc.*, 1960, **29,** Oct., 819–825; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 554) [No abstract].—C.F.C.

On the possibility of alloying weld surfacings with ceramic fluxes L. Pejša (*Zváranie*, 1961, **10,** (5), 136–139) [In Czech] In repairs carried out by automatic submerged arc-welding, advantageous alloying of the weld can be achieved by using plain carbon steel electrodes in conjunction with an alloy-bearing slag. The latter is easily procured, and is readily prepared from slags obtained in previous submerged arc-welding operations. The technological and economic aspects of the method are discussed on the basis of the author's experiments.—P.F.

The present-day development of covered electrodes for arc welding of ferrous materials K. L. Zeyen (*Wire*, 1960, **48,** Sept., 114–120; Oct., 209–214).

The planning and design of arc fusion welded structures: construction in welded plates. I O. Grossi (*Ing. Mecc.*, 1959, **8,** Aug., 7–15) A short technical review of welded steel plates for liquid and gas tanks, both rectangular and spherical, and for gasometers, supported by six detailed tables and diagrams of a variety of joints.—S.H.-S.

Cooling time and brittleness of various steels submitted to welding. 5. On unnotched bending test and tensile test of 35 ~49 kg/m² mild steels and 50 kg/m² high tensile steels H. Sekiguchi, M. Inagaki, and K. Inamiya (*J. Japan Welding Soc.*, 1960, **29,** Aug., 605–610; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 552) [No abstract].—C.F.C.

Welding of 2¼Cr-1Mo steel. 2. The effect of post heat treatments on the creep rupture strength T. Nemoto, R. Sasaki, and T. Yaegashi (*J. Japan Welding Soc.*, 1960, **29,** Aug., 623–628; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 553) [No abstract].

The role of hydrogen in arc welding with coated electrodes N. Christensen (*Weld. J.*, 1961, **40,** April, 14s–154s) The sources and subsequent effects of H_2 in covered-electrode welding are discussed and analyzed, and the role of H_2 in acceptance testing is reviewed.

Influence of residual stresses and metallurgical changes on low-stress brittle fracture in welded steel plates A. A. Wells (*Weld. J.*, 1961, **40,** April, 182s–192s) A review of information now available on welded and notched wide plate and pressure vessel tests, where failure is induced by slowly applied loads, so that features are exposed relating to crack initiation and propagation, together with the influence of some types of naturally occurring flaws. Plate thicknesses surveyed range from ½ to 3in.

Some metallurgical aspects of CO_2-shielded-arc welding M. D. Randall, P. J. Rieppel, S. L. Hoyt, and A. F. Chouinard (*Weld. J.*, 1961, **40,** April, 169–174s). A report, based on five years' past experience, on the soundness of the process with its high resistance to both cold and hot cracking.—S.H.-S.

Oxygen in mild steel weld metal K. Kato (*J. Japan Welding Soc.*, 1960, **29,** Aug., 593–598) from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 554) [No abstract].—C.F.C.

A study on relations between the micro crack initiation and the welding procedure in a fillet joint of thick steel plates. 1 H. Kihara and W. Matsunaga (*J. Soc. Naval Arch. Japan*, 1960, Dec., 327–346; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 554) [No abstract].

Weldability of quenched and tempered steel H. Haruki, H. Kawai, and M. Mitsutani (*Mitsubishi Zosen*, 1960, **8,** Dec., 106–109; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 553) [No abstract].—C.F.C.

Cooling rates in stainless steel welds H. Suzuki and S. Shimizu (*Rep. Nat. Res. Inst. Metals*, 1960, **3,** Aug., 234–241; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 553) [No abstract].—C.F.C.

Cooling rates in stainless steel welds H. Kihara, H. Suzuki, and M. Shimizu (*J. Japan Welding Soc.*, 1960, **29,** Oct., 805–811; from *Japan Sci. Rev. Mech. Eng.*, 1961, **7,** Feb., 552) [No abstract].—C.F.C.

Continuous cooling transformation diagrams of steels for welding and their application. 1–2 H. Sekiguchi and M. Inagaki (*J. Japan Welding Soc.*, 1960, **29,** Aug., 577–587; Oct., 777–786; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 552) [No abstract].—C.F.C.

Effect of alloying elements on notch toughness of basic weld metals. 5. Effect of phosphorus H. Sakaki (*J. Japan Welding Soc.*, 1961 **29,** Dec., 940–945; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 552) [No abstract].

A study of high temperature stress rupture properties of a large welded joint of stainless clad steel for an atomic reactor H. Suzuki, T. Bada, and O. Takagi (*Rep. Nat. Res. Inst. Metals*, 1960, **3,** Dec., 345–363; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 552) [No abstract].—C.F.C.

Hot ductility of stainless steels during weld thermal cycle. 2. Investigation of AISI type 347, 304 and 304L alloys H. Suzuki, T. Bada, and H. Nakamura (*J. Japan Welding Soc.*, 1960, **29,** Dec., 946–955; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 552) Bars and plates of three alloys and of steels were tested. Plate was more ductile than round bar and the phenomena were related to embrittlement by grain boundary liquation. Above 900° all fractures, except in 304L, were intergranular. **3** (*Rep. Nat. Res. Inst. Metals*, 1960, **3,** Aug., 212–222; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 552) [No abstract].

Quality control of welded fabrication S. Rowden (*Sheet Metal Ind.*, 1960, **37,** 667–670).

Brittle fracture strength of welded steel plates A. A. Wells (*Brit. Weld. J.*, 1961, **8,** May, 259–277) The results of tests on five steels in the form of 60 steel plates, each 3 ft wide and 1in thick, are presented and discussed. The steels were: P, semi-killed mild steel; Q, semi-killed mild steel with a higher Mn:C ratio; and R, S, and T, fully-killed grain-controlled normalized mild steels. The results are summarized, tabulated, and analyzed in detail.

Hydrogen and delayed cracking in steel weldments E. P. Beachum, H. H. Johnson, and R. D. Stout (*Weld. J.*, 1961, **40,** April, 155s–159s) The combined effects of H_2 and stress on delayed cracking in steel welds of several common compositions, both carbon and alloy, were investigated, with the conclusion that (a) H_2 and restraint can cause weldment delayed cracking, (b) susceptibility is greater for higher strength base plates and weld metals, (c) residual H_2 content does not correspond closely with welding gas composition.

A study of weld cracking in high strength steels H. Suzuki, M. Inagaki, and H. Nakamura (*Rep. Nat. Res. Inst. Metals*, 1960, **3,**

Oct., 288–306; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 554) [No abstract].

A study of weld cracking of austenitic stainless steels for reactor vessels (3) H. Suzuki and H. Nakamura (*Rep. Nat. Res. Inst. Metals*, 1960, **3**, Aug., 223–233; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 554) [No abstract].—C.F.C.

Cooling time and brittleness of various steels submitted to welding. (6) On [unnotched bending tests of] 60 and 90 kg/mm² high tensile steels H. Sekiguchi, M. Inagaki, and K. Inomiya (*J. Japan Welding Soc.*, 1960, **29**, Oct., 799–804; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 552) [No abstract].

Cracking of steel tubes of tubular scaffoldings J. Teindl and E. Kamenská (*Sborník (Ostrava)*, 1960, **6**, (8–9), 855–861) [In Czech].

Determination of the causes of weld-metal cracking in high-strength steels and the development of heat-treatable low-alloy-steel filler wires for use with the inert-gas-shielded arc-welding process H. W. Mishler, R. E. Monroe, and P. J. Rieppel (*PB* 161981, Rept. for June 58–July 59, on Welding, Brazing, and Soldering of Metals, 1960, May, pp.60; *WADC Technical rept.* 59–531; from *US Res. Rep.*, 1960, **34**, Dec. 16, 759) S and P should be below 0·025% in 4340 steel. An intergranular phase, apparently Fe–P eutectic, seems to be associated with hot cracking. Filler wires developing high strengths were produced.

Single-pass 'J' grooving in heavy plate with an oxy-fuel gas flame C. B. Milton (*Weld. J.*, 1961, **40**, April, 331–338).

A new precision oxy-flame cutter Suffolk Iron Foundry Ltd (*SIF–TIPS*, 1961, **26**, Spring, (111), 21–22).

Method of fully automatic gas cutting H. Kitano and M. Tsutsumi (*Harima Zosen Tech. Rev.*, 1960, Oct., 21–28; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 556) [No abstract].—C.F.C.

Quality classification of flame cuts E. Zorn (*Schweissen Schneiden*, 1961, **13**, June, 226–229) [In German] Aspects dealt with include characteristics of the proposed quality classification, numerical values for the characteristics, measuring equipment, system of figures for specifying quality of flame cuts—combination of single quality grades to total quality grades which serve for judging the quality of flame cuts and for determining tolerances.

MACHINING AND MACHINABILITY

New theories on machining metals T. Bruzzone (*Ing. Mecc.*, 1960, **9**, Dec., 7–13).

Machining standard of G18B high class heat-resistant steel. [Study on establishment of machining standard. 5] H. Takeyama, U. Kasuya, and A. Yamada (*Seimitu Kikai*, 1960, **26**, Dec., 731–739; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 564) The 5th report of the extensive project to establish machining standards for standardized materials. The process for obtaining the standard for turning high-class heat-resistant steel G18B (JESSOP) is reported. The machinability of the material is thoroughly investigated based upon the tool life.—C.F.C.

Machinability of nodular cast irons. Part I. Tool forces and flank adhesion I. Ham, K. Hitomi, and G. L. Thuering (*Trans. ASME*, 1961, **83B**, May, 142–154) Three grades of nodular cast iron (60, 80, and 100), were tested to determine the performance of several grades of carbide and oxide cutting tools, and to investigate flank adhesion. Cutting characteristics for grade 80 and grade 100 were the same as for high-strength grey cast irons with similar Bhn values. Flank adhesion was only encountered when grade 60 was machined with carbide tools. An attempt was made to correlate tool composition and flank adhesion.

Free machining steel: I. Tool-life characteristics of resulphurized steel M. C. Shaw, N. H. Cook, and P. A. Smith (*Trans. ASME*, 1961, **83N**, May, 163) Tool-wear and tool-life characteristics of a series of five steels of different sulphur content are presented for different values of cutting speed, feed, cutting fluid, and cold work, and results are reported for the group of hot-rolled steels studied. A tracer device is described that is useful in exploring the nature and extent of the crater and built-up areas on the tool face. **II. Tool-life characteristics of leaded steel** (175–180) High-speed steel tool life results are presented, and discussed for a leaded and non-leaded steel from the same heat. Variables investigated included cutting speed, feed, cutting fluid, and cold work. **III. Cutting forces: surface finish and chip formation** M. C. Shaw, E. Usui, and P. A. Smith (*Trans. ASME*, 1961, **83B**, May, 181–193) Tests on friction sliders reveal MnS as a poor solid lubricant relative to air, whereas lead is excellent. Cutting force results are presented for a wide variety of cutting conditions for both resulphurized and leaded steels. Both lead and sulphur are found to produce thinner chips, promote chip curl, and give rise to a shorter contact length between chip and tool.—S.H.-S.

Influence of cold working carbon steels on their machinability E. Bodart and L. Czaplicki (*Microtecnic*, 1960, **14**, Dec., 255–257) From the investigations described, undertaken jointly by CRIF and CNRM, it is concluded that the machinability of the C steels examined was improved by cold drawing.

The machining of steel. II. Planing and shaping machines F. C. Lea (*Edgar Allen News*, 1960, **39**, Dec., 269–270).—C.V.

Study on free-cutting 13Cr stainless steels containing Se H. Takada and T. Suzuki (*Tetsu to Hagane*, 1960, **46**, Sept., 1382–1383) The chemical composition of steels tested is given as well as the results of mechanical tests and a comparative curve of cutting efficiencies.

Special metal removing machine tools K. W. Michler (*Metall*, 1960, **14**, Dec., 1174–1181) Several recent types of precision machine tools which have given high production rates are described and illustrated.

The flow chip formation in the orthogonal cut W. Scholz (*Metall*, 1960, **14**, Sept., 891–896).

New machining methods needed for heavier space-age metals K. Sparling (*SAE J.*, 1961, **69**, March, 74–76) The author describes such electrical machining methods as electron beam, electric spark discharge and electrolytic grinding. He then deals with ultra-high-speed machining, chemical milling, and thermal machining.—A.H.M.

Face milling of carbon steel 550C with carbides. [Study on carbide milling. I] H. Takeyama and A. Yamada (*Seimi tu Kikai*, 1960, **26**, Nov., 674–685; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 564) The final object of this study is to establish the operating standard of face milling with carbide tools in terms of tool life. The most suitable carbide grade the best combination of tool shape, the effect of cutting speed, feed, depth of cut, engage angle, and width of work material on frequency of shocks upon the tool life are investigated. The tool wear in carbide milling is characterized by the fact that the shock against the tool tip due to the engagement with work material plays an important role in its process, whereas the temperature plays only a minor role. The key point, from every standpoint of face milling with carbides is how to prevent chipping.—C.F.C.

What's the secret behind good cutting C. P. Farr (*Metalw. Bull.*, 1960, **23**, Nov., 44–46).

Problems in connection with the measurement of variable cutting-edge forces of tools E. Bickel (*Microtecnic*, 1960, **14**, Oct., 226–232).

Qualities and structure in steels and metals. Influence of the geometric factor in qualitative and quantitative determination G. Arregui (*Met. Electr.*, 1960, **24**, Oct., 84–90) The review is concluded with a discussion on quantity in relation to the mechanization and machinability of steels other causes of deformation and alterations of granular structure in steels with their theory and technology, qualities, worked structures in the metal, the correct and incorrect structure of forgings, with a brief summary.—S.H.-S.

On the causes of wear of tools G. Ostermann (**Industrie-Anzeiger*, 1959, **81**, Aug. 4, 13–21).

Flank wear on a sintered oxide (ceramic) tool bit A. Gibson (*Microtecnic*, 1960, **14**, Oct., 239–243).

Tool wear when cutting thin sheet material H. J. Crasemann (*Microtecnic*, 1960, **14**, Feb., 25–29) A report of work carried out at the Technische Hochschule, Hanover, on the wear of the punch and die used for cutting sheet material.

Interaction between tool and workpiece materials during the cutting of metals T. N. Loladse (**Industrie-Anzeiger*, 1959, **81**, (62),; 21–26 (991–996)) An investigation on the phenomena occurring in the contact area between tool, workpiece and chip is presented as well as the processes taking place during the interaction of tool and workpiece materials. It is reported that suitable cutting edge materials and machining conditions can be determined in advance for each workpiece material, depending on its chemical composition and mechanical properties.—S.H.-S.

Concerning the correlation of cost accounting between blank-manufacturers, machine shops and the customer I. E. Moshkevich and A. D. Kissin (*Stal'*, 1961, (5), 456–457).

Determination of the principal cutting force in the planing machine M. Tripa and I. Pastrav (*Inst. Politeh. Cluj, Lucrari Stiint.*, 1960, 343–347).

Effects of clearance and rake angles on tool life E. Bodart and G. Andri (*Microtecnic*, 1960, **14**, Feb., 30–33).

A study on carbide and cutting durability of high-speed steels S. Koshiba, S. Kimura, and J. Harada (*Hitachi Rev.*, 1960, **9**, 28–31; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 591) [No abstract].—C.F.C.

Trial production of sintered carbide face milling cutters M. Harad, M. Okoshi, andN. Shinozaki (*Okoshi Lab. Rep. Inst. Phys. Chem. Res.*, 1960, **36**, (5), Sept., 429–443) The authors discuss the various types of face milling cutters on the market. They point out that these cutters are far from ideal as far as their operation and durability are concerned. In some previous reports descriptions were given of a new type of cutter and this report describes the design and manufacture of the new cutter. Though the operation of this cutter is similar to that of previous ones, its durability is such that it has a life-expectancy of several times that of the old ones. A description is also given of three new types of inside cutters.

Relation between cutting condition and surface roughness in external finish turning N. Yamada, T. Gotô, and Y. Tanaka (*Hitachi Zosen Giho*, 1960, **21**, Nov., 238–246; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 565) [No abstract].—C.F.C.

Dynamical measuring of cutting forces on a lathe dynamometer. (4) T. Masuda and S. Mizukami (*Res. Rep. Kogakuin Univ.*, 1960, Dec., 43–48; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 564) [No abstract].

On ceramic cutting tools—comparison of the life of carbide tools with that of ceramic cutting tools M. Nozoe (*Mem. Fac. Engng. Kagoshima Univ.*, 1960, Aug., 17–22; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 562) [No abstract].—C.F.C.

On the cutting durability of high-C high-V Co high-speed steel S. Koshiba, K. Tanaka, and A. Sumi (*Hitachi Rev.*, 1960, **9**, (1), 25–28; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 591) Five types of high-speed steels containing 1·12∼1·59%C and 3·33–4·87%V are reported of their heat-treating properties (in relation to hardness), austenitic grain size, and ultimate bending strength as well as their deflection and cutting durability. These are compared with a standard high-speed steel containing 10%Co and other conventional high-speed steels. Two samples containing 1·57∼1·59%C and 4·72∼4·87%V besides about 5%Co show high cutting durabilities comparable to that of a standard (18–4–1 type) high-speed steel with 10%Co.—C.F.C.

Machining standard of alloy steel SNCM8. [Study of establishment of machining standard. 6] H. Takeyama and U. Kasuya (*Seimitu Kikai*, 1960, **26**, Dec., 739–746; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 564) The process to find out the best machining conditions of heat-treated alloy steel SNCM8 is described. The main items included are: tests for selecting the best carbide grade and the best tool shape for the material; the effect of feed and depth of cut; establishing the machining standard by means of tabulation or nomograph.—C.F.C.

Effect of hardenability on development of

cracks in tools E. I. Malinkina (*Met. Treating*, 1961, **12**, April–May, 12–14, 35) Results are reported of a study of formation of cracks in shank tools of 1·0 and 1·2%C steels as affected by cross-sectional area. The effect of quenching temp. on the number and shape of cracks is studied and an analysis made of the factors governing the formation of the various types of cracks. The paper is concluded by a study of the susceptibility of fully and incompletely hardened tools to cracking.—A.H.M.

On the heat transfer properties of aqueous cutting fluids. (3) A. Yamamoto and N. Shibuya (*Seimitu Kikai*, 1960, **26**, Dec., 747–750; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 562).

The physical foundations of the electric spark machining of metals B. R. Lazarenko (*Vestnik, Akad Nauk*, 1959, **6**, 49–56) An explanation is given of electric spark-machining of metals in terms of the electrodynamic and magnetodynamic forces operating.

CLEANING AND PICKLING

Solvent degreasing: A description of a continuous automatic solvent degreasing plant Dawson Bros. Ltd (*Corros. Prev.*, 1961, **8**, June, 51–52).

Stain-free drying of metal parts E. Plassmeyer (*Products Fin.*, 1960, **25**, Dec., 62–64).

Modern polishing and buffing S. P. Sax (*Met. Fin.*, 1960, **58**. Oct., 51–55; Nov., 44–47, 52).

New stainless steel annealing and pickling line provides for three strand operation at J. & L. Youngstown, Ohio Plant (*Indust. Heat.*, 1960, **27**, Sept., 1788–1796) The new line makes the plant capable of producing all types of finish on annealed stainless strip. It will be used for annealing and pickling types 430 martensitic and 300 Cr–Mn austenitic steels. Details are given of the strand control, atmosphere-furnace annealing, salt-bath descaling, electrolytic pickling, and scrubbing and drying.—K.E.J.

Addition of common salt to the pickling melt N. P. Zhetvin (*Stal'*, 1961, (6), 570) A note from 'Serp i Molot'. A $NaOH/NaNO_3$ bath with 5%NaCl at 450–475°C is recommended.

Dissolution of iron in sulphuric acid and ferric sulphate solutions A. C. Makrides (*J. Electrochem. Soc.*, 1960, **107**, Nov., 869–877).

Inhibition of metal dissolution by ferric sulphate A. C. Makrides and M. Stern (*J. Electrochem. Soc.*, 1960, **107**, Nov., 877–883).

Continuous electrolytic contactless pickling of stainless steel strip and wire N. P. Zhetvin (*Stal'*, 1961, (6), 570) A note from 'Serp i Molot' Optimum bath composition for six high-alloy steels is given. Wire is pickled in 12 sec with a c.d. of 30–40 amp/dm² and strip in 7½ sec with 10–15 amp/dm².

A pre-production test for acid inhibitors R. H. Hertzog (*Wire Wire Prod.*, 1960, **35**, March, 327, 385–386) Tests on new materials in general are described and a method for testing the efficiency of new inhibitors is presented with a formula which may be varied to suit local conditions and preferences in regard of acid temp.—S.H.-S.

The problem of pickling liquor regeneration K. Abramov (*Hutník*, 1961, **11**, (5), 223–226) [In Czech] Various existing methods of regeneration are discussed. A Soviet electrolytic method yielding H_2SO_4 and 40–80 g/l of iron is considered most appropriate under Czechoslovak working conditions, and its wider introduction and study are advocated.—P.F.

Industrial electrolytic polishing of aluminium and steels in Japan S. Tajima (*Metalloberfläche*, 1960, **14**, Aug., 246–256).

Electrocleaning: A report of current practice L. McDonald, R. L. Racine, and C. N. Chalfont (*Products Fin.*, 1961, **25**, Jan., 50–60) Discussion between the three authors on the current practice of electro-cleaning.—A.W.D.H.

Lines of development in electrolytic and chemical polishing R. Pinner (*Metalloberfläche*, 1960, **14**, Aug., 256–260).

An investigation of electropolishing as a technique for producing tapered wire D. B. Darden (*PB* 149353. *Final technical report*, May 59–March 60; from *US Res. Rep.*, 1960, **34**, Dec. 16, 735) Cost estimates are included.

An investigation of electropolishing as a technique for producing tapered wire D. B. Darden (*PB* 149848, *Technical note No.2*, Dec. 59–Feb. 60; From *US Res. Rep.*, 1960, **34**, Dec. 16, 735) Steel music wire and 302 stainless were used. Strength was measured after electropolishing down to 0·02in.

Comparative investigations into the chemical and mechanical descaling of rolled wire, taking into account the machineability during subsequent cold forming processes M. Buch (*Wire*, 1960, Dec., 225–232) Comparative results showing the structure of mechanically descaled and of pickled wire, machineability with special reference to drawing properties, condition of wire to be hot-dip galvanized or formed into wire pins and effects of lubricants are reported and discussed, with reference to the literature.

The salt bath descaling method—the sodium hydride and Kolene-15 method R. Kuhn (*Wire*, 1960, (48), Aug., 168–169).

Shot blasting machines for descaling bars L. Kus (*Hutnik*, 1961, **28**, (3), 131–133) An account of a German machine described in *Stahl u. Eisen*, 1958, (6), 258–264).

Scale on wire rod and its removal by mechanical means. Part 3 S. Garber and G. M. Sturgeon (*Wire Ind.*, 1961, **28**, May, 467–470) After a brief historical review of mechanical descaling since 1941, the two main methods of mechanical descaling are presented, covering removal by bulk deformation of both primary and secondary scale, removal by shot-blasting, with a discussion on problems associated with mechanical descaling. The BISRA nozzle-die-unit, its arrangement and use are also described.—S.H.-S.

The treatment of pickling lye and effluents of the iron-processing industry with the aid of ion-exchange diaphragms H. Quitmann (*Wire*, 1960, Oct., 204–208).

Treatment of waste acid from pickle and scrubbing lines M. Smallwood (*Sheet Metal Ind.* 1960, **37**, Sept., 675–680) The author describes the procedure adopted by the Abbey Works of the Steel Company of Wales to meet the stringent attitude of the River Board concerning polution. The plant is described and tables given of the chemicals handled together with their composition.—A.H.M.

PROTECTIVE COATINGS

Vapour-plating and vacuum deposition processes. [Review] H. Ezaki (*J. Metal Finish. Soc. Japan*, 1960, **11**, 310–314; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 556) [No abstract].

Science for electroplaters. 61. Adhesion tests L. Serota (*Met. Fin.*, 1960, **58**, Nov., 65–69).

Control of chromium plating baths J. P. Branciaroli (*Products Fin.*, 1960, **25**, D3c., 50–56).

Chromium plating of the bore of the 7·92 millimetre CETME rifle L. L. Morales (*Met. Elect.*, 1961, **25**, May, 152–158).

Chromium electroplates for corrosion protection of stressed AISI 410 steel in high-temperature, high-purity waters H. Suss (*USAEC Report KAPL*–2000–9 (*TID*–4500, 15*th Ed.*), 1960, March, B.15–B.21) A test to evaluate the use of Cr plate for corrosion protection of AISI 410 tempered at both 650 and 1125°F coated with chromium from four different suppliers is reported, with results producing wide variations in appearance and characteristics, followed by a discussion.—S.H.-S.

A study of the minimization of the adverse effects of chrome plating on the fatigue life of AISI 4340 steel and the correlation of fatigue and elastic limits J. Viglione (*PB* 150787, Rept. on Proj. *TED NAM AE* 4110, pt.13, 1959, July, pp.38; *Rept. No. NAMC–AML–AE*–1098; from *UA Res. Rep.*, 1960, **34**, Dec. 16, 759) The effect of shot-peening prior to and baking after chrome plating AISI 4340 steel was investigated at strength levels up to 295000 psi. It was found that this treatment had excellent beneficial effects on the fatigue limits of chrome plated 4340 steel at all the strength levels likely to be used in aircraft construction. It was determined that there was no relationship between the fatigue limits and any of the other mechanical properties of the plated steel. In the case of the unplated steel, it was established that there was a definite straight-line functional correlation between the fatigue limit to elastic limit ratios and the tensile strength levels of the steel.

Testing waste from chromium plating A. J. D'Orazio (*Met. Prog.*, 1960, **78**, Dec., 124).

On the adhesion test and adhes on value of chromium plating Y. Kamino (*Hitachi Zosen Giho*, 1960, **21**, Nov., 205–211; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 485) [No summary].—C.F.C.

Improved nickel–chromium processes H. J. Bache (*Electropl. Met. Fin.*, 1960, **13**, Dec., 451–455, 472) It is considered that although at the moment there are technical and economic objections, a combination of Ni (or Cu)–Cr–dual Ni–Cr is the most satisfactory answer to the problem of corrosion resistance.—C.V.

Hard chromium plating of cylinder liners (*Electropl. Met. Fin.*, 1960, **13**, Nov., 430–431).

Automatic platers hard chrome 80 liners an hour (*Metalw. Prod.*, 1960, **104**, Oct. 19, 86–87).

Direct nickel plating of hardenable stainless steel B. E. Scott (*Met. Fin.*, 1960, **58**, Nov., 48–52) The development of a procedure for Ni plating AISI Type 410, 12%Cr stainless steel is described. Pickling in concentrated HCl was followed by direct plating with sulphamate nickel. The fatigue properties of rotor blades were unaltered by this coating which gave protection in marine environments.

Nickel plate cuts buffing costs C. Bush (*Products Fin.*, 1961, **25**, Jan., 76–78).

pH change in nickel plating R. G. Maling (*Electropl. Met. Fin.*, 1961, **14**, June, 191–196) Experimental investigation of changes in the pH of nickel plating, and allied solutions, produced by acid and alkali additions, and application of the results to electroplating practice.

Why barrel zinc plating of carbonitrided steel is difficult N. F. Murphy (*Products Fin.*, 1961, **25**, Jan., 84–90).

Color finishing of galvanized steel (*Met. Prog.*, 1960, **78**, Dec., 105–110).

Selection of steel plate for zinc plating kettles I. Nakamura, T. Yamane, and S. Okumura (*Hitachi Zosen Giho*, 1960, **21**, Nov., 212–216; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 589) High-tensile steel plates are not always good for zinc dip-plating kettles in respect of erosion by molten zinc, and it sometimes happens that steel plates produced by primitive processes show rather a better erosion resistance. The present researches reveal that: (1) low carbon steel generally shows good erosion resistance, steel of about 0·1%C is the best for practical purposes, (2) deoxidized steel has good erosion resistance, and high-Si or high-Mn steels have not but Al-deoxidized steel is good; (3) the molten zinc bath is erosive at about 500°C because of the peritectic reaction which occurs in Fe–Zn alloy at that temp. For prolonged use, the temp. should be below 450°C.—C.F.C.

On control of the chemical plating bath. (I) [Studies on chemical plating–5] B. Ro and S. Matsumoto (*J. Metal Finishing. Soc. Japan*, 1960, **11**, Dec., 681–685; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 556) Reducing reagent must be added to the chemical plating bath within about 1 h before the plating operation, and the pH must be adjusted with ammonia or H_2SO_4 solution. Variable factors of the chemical plating bath are nickel-ion and hypophosphite-ion concentrations, pH, impurities, etc. Temp. of the plating operation also affects quantity and lustre of the deposit.

The influence of some factors, particularly that of basic Bessemer steel, on the quality of tinplate J. Teindl (*Pišek's Sborník*, 1956, 263–270; reprint) The chemical composition of sheets for tinning, and the kind of steel (basic Bessemer or OH steel) are very important factors in the corrosion of tin cans. Opinions differ very much in this respect. The author referring to the results of the experiment, recommends a steel with a small addition of Si (about 0·08 up to 0·1%) in order to improve quality of sheet-surface and decrease the tin coating. Comparing sheets from basic Bessemer steel with those from open-hearth steel, the author concludes that for common tin cans sheets from basic Bessemer steel are suitable too as shown by sheet testing and classifying.—C.F.C.

Hot-dip aluminising of steel wire: laboratory scale investigations and pilot plant studies A. N. Kapoor, P. K. Gupte, and B. R. Nijhawan (*NML Pilot Plant Symp.*, 1960, July, 188–196) Experimental work carried out at the Protective Coatings Laboratory of BISRA at Swansea is reported, as the basis for the establishment of a pilot plant for the Jamshedpur National Metallurgical Laboratory.—S.H.-S.

Hot-dip aluminium coating on steel. 8. Corrosion resistance property of aluminized steel in various hot aqueous solutions M. Tagaya, S. Isa, and H. Harima (*J. Metal Finish Soc. Japan*, 1960, **11**, Dec., 685–690; from *Japan Sci. Rev. Mech. Elect. Engr.*, 1961, **7**, Feb., 489) Behaviour in distilled water, tap water, NaCl, H_2SO_4, and $Al_2(SO_4)_3$ solution is indicated.—C.F.C.

Copperizing of steel wire T. Dolnicki (*Hutnik*, 1961, **28**, (3), 124–127) The wire was passed through a bath containing 1·0–2·0% H_2SO_4 and 3%$CuSO_4$, $5H_2O$. Time of retention was 30 sec and 1 kg $CuSO_4$, $5H_2O$ was required per 1 t of wire. When drawn the amount of copper deposited sharply decreased after 2nd deformation but then from 3rd deformation onwards it remained constant at about 50% of the copper deposited. Copper deposited from a neutral bath was less resistant to abrasion during drawing.

Anodising copper, magnesium, zinc, cadmium, steel, and silver N. P. Fedot'ev and S. Ya. Grilikhas (*Electropl. Met. Fin.*, 1960, **13**, Nov., 413–417) —S.H.-S.

The chromic acid anodising bath, and its control H. A. Prelinger (*Met. Fin.*, 1960, **58** Nov., 59–61).

Electrical insulating properties of phosphate layers H. H. Reinsch (*Metall. Rein. Vorbeh.*, 1960, Dec., **9**, 214–218).

Organic and metallic finishes R. J. Brown (*Met. Ind.*, 1961, **98**, March 3, 167–170) An account of car finishes.

Organic coatings for steel sheets and strip Y. Kitamura (*Tetsu-to-Hagane*, 1960, **46**, Dec., 1777–1797) [In Japanese] [No Summary].

Four ways to coat steel with plastics (*SAE J.*, 1960, **68**, Sept., 30–33) The article is based on four original papers and describes the laminating and the plasticized processes used in producing vinyl-coated steel, (the Marvibond, Whirlclad, Kaybar, and US Steel processes). It is pointed out that the two processes result in products with the same characteristics. In the plasticized process the vinyl is applied dry, as liquid or in fluidized powder form. The plasticized process has the advantage of producing a continuous coating.—A.H.M.

Neoprene and 'Hypalon'-based coatings V. Romanovsky (*Corros. Techn.*, 1960, **7**, Dec., 400–403) A description of a series of corrosion tests carried out by the French Oceanographic Research Centre on five types of coatings based on neoprene and Hypalon synthetic rubbers, and immersed in sea-water.

Lining steel tanks with plasticized P.V.C. (*Electropl. Met. Fin.*, 1960, **13**, Dec., 445–448, 450).

Electrophoretic coatings on steel B. W. Burrows (*Broken Hill Res. Div. Inf. Circ. No.*9, 1960, Feb. 10, pp.5) The use of electrophoretic deposition in theory and practice is discussed, and some tests are described, with data on preparation of the coating suspension, deposition, and bonding and densification. The control of coatings to close tolerances, and some economic advantages as compared with electroplating, are briefly mentioned.—S.H.-S.

Selection and application of temporary protective treatments E. C. Kuster (*IAAE J.*, 1961, **21**, Feb., 29–31) Mainly in terms of Australian specifications.—A.W.D.H.

20 years protection for the steelwork (of the Forth Road Bridge) (*Engineering*, 1961, **191**, March 31, 449–450).

Stran-steel's color-coating process G. H. Poll jun. (*Products Fin.*, 1960, **25**, Dec., 30–47) Description of an automatic continuous plant for spray painting zinc coated corrugated steel sheet.—A.W.D.H.

Researches on the painting of galvanized sheets G. Odone, G. Milanese, and E. Dellepiane (*Acier-Stahl-Steel*, 1960, **25**, Nov., 493–498) A series of tests, with details of composition of paints exposed to sea air for a year, and after 100 h in salt spray, compared with unexposed test pieces. The resulting treated test pieces are classified for blistering and chalking; climatic characterizations, including solar radiation, rain, mean humidity, and condition of sky, are reported, and the results discussed.

Paint performance on grit blasted ships' hulls J. C. Rowlands (*JISI*, 1961, **199**, Dec., 329–333) [This issue].

Roller coat painting aluminium and steel on same line Seaview Industries Inc. (*Products Fin.*, 1961, **25**, Jan., 78–79).

Paints and zinc coatings used to protect steel in buildings against corrosion P. Blancheteau (*Corros. et Anticorros.*, 1960, **8**, Dec., 451–461) [In French] Anti-rust or metallic Zn paints are most frequently used to protect steel in buildings. Galvanizing spray metallizing and electrolytic coating are now used in steelworks to protect sheets and sections as a finishing process. The methods of application and advantages of these various protective coatings.

CLAD SHEET AND HARD-FACING

Experiments on the relation of Stellite surfacing and gas flames I, Sakakibara, S. Ushioda, and T. Hayashi (*J. Japan Welding Soc.*, 1960, **29**, Aug., 611–614; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 556) [No abstract].—C.F.C.

Overlay welding of stainless steel for a reactor vessel T. Kurokawa and M. Nakajima (*Mitsubishi Zosen*, 1960, **8**, Dec., 132–137; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 456) [No abstract].—C.F.C.

Some properties of composite steel with a coating of titanium carbide H. Weigand and W. Ruppert (*Metalloberfläche*, 1960, **14**, Aug., 229–235) The appearance, chemical behaviour, structure, physical properties, and possible applications are described of steel and cast iron with coatings of compacted titanium carbide (21 refs).

POWDER METALLURGY

Sintered nickel steels W. V. Knopp (*Pred. Met. Mold.*, 1960, **18**, Oct., 48–49) Various commercially available iron powders were used; two, a reduced and an electrolytic, were examined under all conditions. The variables investigated were: Final C-content 0 to 0·5, 0·75, and 1·0%Ni additions 0, 2, 3–5, 7, and 9%, lubricant $\frac{1}{2}$%Zn-stearate, compacting pressure 50 t/in^2, sintering temp. 2005 and 2200°F, sintering time $\frac{3}{4}$ and $1\frac{1}{2}$ h, an atm. of dry H_2 was used. The Ni-powder used was carbonyl-Ni (Grade B). The effects of compacting pressures and heat treatment are tabulated and it is shown that for the 2050°F sinter at $\frac{3}{4}$ h, as quenched and tempered at 400°F the tensile strength increased from 78000 to 150000 psi.—C.V.

Sintering of iron–carbon copper compacts K. Seto, T. Seto, and S. Iwasaki (*J. Japan Soc. Powder. Met.*, 1960, **7**, Aug., 149–155) [In Japanese] Carbon content in steel increases the tensile strength and hardness. To increase strength of sintered parts a mixture of reduced sponge iron powder MH 100, a very fine flaky graphite (−1000 mesh) and fine dendritic electrolytic copper powder was used. Some abnormal phenomena include the remarkable shrinkage at the points of 6–10%Cu and 1–2% graphite contents in the case of the Fe–C–Cu compacts, while the Fe–Cu system shows noticeable copper growth at the copper range 7–9% and the C–Fe system has the small dimensional change.—R.S.F.C.

Copper-steel dog withstands impact Eaton Manufacturing Co. (*Prec. Met. Mold.*, 1960, **18**, Oct., 74).

Sintered stainless steel powders R. L. Sands and J. F. Watkinson (*Prec. Met. Mold.*, 1960, **18**, Dec., 41–42) Mo, Si, and possibly Nb adversely affect green density and increase shrinkage during sintering and it is considered essential that with pressing loads of 30–50 t/in^2 these powders must give high green density and adequate strength; after sintering, the compacts must possess high mechanical strength (2100°F in dissociated NH_3) and shrinkage is limited to 1%. Chemical composition of the powders, particle size distribution, flow rate, apparent density and green properties (without lubricant and with 0·5%Li stearate) are tabulated.—C.V.

The application of cold-powder extrusion and sintering to the fabrication of stainless steel–UO_2 fuel elements H. G. Sowman and G. L. Ploetz (*US AEC Research and Development Report, KAPL*–1345, 1955, June 3, 7–15; from *US Res. Rep.*, 1960, **34**, Dec. 16, 807) An alternative method of fabricating a pin-type stainless steel–UO_2 dispersion-type fuel element was attempted, and the process involved the cold-extrusion of the stainless steel and UO_2 powders with an organic binder lubricant. After hot-working the sintered core in a stainless steel cladding, the microstructure, density, UO_2 particle shape, bending, and resistance to He penetration were found to be excellent.

PROPERTIES AND TESTS

Properties, structures and characteristics of metals and ceramics L. H. van Vlack (*ASM Met. Rev.*, 1960, **33**, Oct., 4–8) An elementary crystallographic and phase diagram exposition.

A comparison of transition temperatures determined by small and large scale tests on five steels (*Admiralty Adv. Comm. Struct. Steel Rep. No.*P.2, 1960, 1–63) A report is presented on a range of eight classes of tests, including Charpy-V-notch, Tipper, Robertson, van der Veen and wide plate, upon five steels as follows: (P) ordinary mild steel, semi-killed, as rolled. (Q) 0·15%C, 1%Mn steel, semi-killed, as-rolled. (R) 0·12%C, 1·4%Mn steel, grain controlled, normalized. (S) 0·15%C, 1%Mn steel, grain controlled, normalized. (T) 0·15%C, 1·4%Mn steel, grain controlled, normalized. Transition temp. values are reviewed, transition temp. are compared, and results are discussed, and suggestions for using the information available from the large accumulation of data afforded by the programme are made.

Influence of delta ferrite–carbide segregates on the properties of 12% chromium steel E. A. Loria (*Trans. ASM Quart.*, 1961, **54**, March, 31–49) Longitudinal and transverse tensile (smooth and notched) impact, stress rupture (smooth and notched), and fatigue (smooth and notched) tests were made on 12%Cr–Mo–W–V steel (Type 422) and the detrimental effects of various amounts of delta ferrite–carbide segregates were determined. By proper balancing of the composition this steel can be produced free of ferrite in ingot sizes up to 26in dia. Solidification in larger sizes (36–55in dia.) produced massive carbides, nonmetallics, and massive ferrite–carbide segregates. In some instances the latter contained an envelope structure resembling pearlite.—S.H.-S.

Comparative test on spring wire of various types of stainless steel T. Fujihara and Y. Motomiya (*Tetsu-to-Hagane*, 1960, **46**, Sept. 1369–1372) Details are given of the chemical compositions and properties of some stainless steels used for springs, the chemical composition of specimens and the effect of heating temp. on hardness and tempering temp. on mechanical properties. The results of load tests on coil springs are given.

Observation of vaporization accompanying ultra-high velocity impact R. W. Bartlett (*PB* 148013, 1960, Jan., pp.26; from *US Res. Rep.*, 1960, **34**, Dec. 16, 758).

The geometrical definition and evaluation of surface roughness in the M-system W. M. de Vries (*Microtecnic*, 1960, **14**, Feb., 23–24).

Mechanical properties of high strength steel in plastic range T. Kusuda and E. Fujii (*J. Soc. Naval Arch. Japan*, 1960, Dec., 365–374; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 592) Studies of combined buckling forces were made on round bars under constant axial load and variable torsional moment.

Mechanics of plastic deformation in polycrystalline metals R. C. Deshpande (*Trans. Indian Inst. Met.*, 1960, **13**, Sept., 241–248).

On the changes of residual stresses resulting from carburizing and quenching due to ageing and repeated stressing S. Taira and Y. Murakami (*Proc. 2nd Japan Congress on Testing Materials*, 1959, 26–29) Specimens of 0·17%C and 0·13%C, 2·16%Ni, 0·38%Cr steels were examined to assess the contribution to fatigue strength of residual stress from carburizing

and quenching. It is concluded that these residual stresses are of the thermal stress type; surface residual stresses tend to decrease during ageing, then increase after seven days and decrease again after a further 15 days. Other effects are reported, including a pronounced increase in fatigue strength after quenching carburized specimens.

Young's modulus and its variation with magnetization in annealed iron–cobalt alloys M. Yamamoto (*Sci. Rep. Res. Inst. Tohoku Univ.*, 1960, **12**, Aug., 291–308) [In English] The negative ΔE effect occurs with weak magnetic fields in most alloys except 45–50% and 100%Co. The curve of $(\Delta E/E_0)$ max. against composition has a sharp, high peak at $\sim$50% Co. The trend of the curve in the α-range can be expressed fairly well by a formula. Young's modulus in the unmagnetized state has max. at 25–30 and 60%Co, and a min at 50%Co, falls to the α-boundary $\sim$80%Co), recovers in the $(\alpha+\gamma)$ range, and falls again in the ϵ-range. Density results are given (23 refs).—K.E.J.

The importance of 'Formdehngrenzen' for the calculation of strength S. Schwaigerer (*Materialprüfung*, 1961, **3**, May 20, 171–175) A calculation method which considers the 'Formdehngrenzen' proposed by E. Siebel for the use in design is discussed. It is shown that it enables economic use of the material and eliminates inadmissable great plastic deformation in the max. stressed cross-section, in the case of design at structural elements which are subject to unequal stresses under static load. The 'Formdehngrenzen' is the stress that would occur in a perfectly elastic body at the same load.—M.L.

Measurement of damping capacity, using pure α-iron and commercial steel H. J. Seemann and H. Finkler (*Annales Universitalis Saraviensis Naturwissenschaften Sciences*, 1956, 87–105; reprint).

Stress-relaxation properties of steels for steam power plant A. I. Smith, D. J. Armstrong, and G. R. Tremain (*Brit. Electric & Allied Ind. Res. Assoc.*, J/E/T 216, 1960, Oct., 8–13) (International discussion on long-time performance of high temperature steels, Düsseldorf, 1960).

An investigation of certain questions of the temperature relationship of steel ductility from the viewpoint of dislocation theory V. G. Savitskii and K. V. Popov (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5**, 150–154) The deformation process was studied in production-grade steel at various temp. and for various stress rates and methods from the viewpoint of dislocation theory. For this purpose steel 20 in the annealed state was chosen (15 refs).—A.I.P.

A note on relaxation testing of steam turbine cylinder bolt materials with simulated retightening J. H. M. Draper (*Brit. Electric & Allied Ind. Res. Assoc.*, J/E/T 216, 1960, Oct., 19–24; International discussion on long-time performance of high-temperature steels, Düsseldorf, June, 1960, Paper 32).

Considerations of the Moiré method in photoelasticity A. Pirard (*Rev. Univ. Mines*, 1960, **16**, April, 177–200).

On notch sensitivity F. A. McClintock (*Weld. J.*, 1961, **40**, May, 202s–209s).

Representation of deformation ratios by flow diagrams and their practical value M. Vater (*Materialprüf.*, 1961, **3**, May 20, 176–180).

Contraction in plane components showing notch stresses H. Motzfeld (*Technik*, 1961, **16** April, 324–325) Contractions in flat components made of light metal or plastics, which are due to plastic flow, can be estimated by the moiré pattern formed by special lacquers, while in the case of transparent plastics a moiré pattern formed by distortion of a series of parallel black and white lines is suitable for the same purpose.—M.L.

Concerning the question of the effect of temperature variation and deformation rate on the properties of steels with differently dispersed carbide inclusions V. D. Kuznetsov, K. V. Savitskii, N. N. Sukharina, V. N. Zhdanova, G. V. Toporov, and A. P. Savitskii (*Issledovaniya po zharoprochnym splavam*, Moscow, 1960, **6**, 56–63) The effect of temp. and deformation rate is greater the smaller the size of carbide inclusions. This is explained by the metastability of slightly dispersed structures. Many other conclusions were reached (14 refs).—A.I.P.

Interaction of interstitials with dislocations in iron K. Kamber, D. Keeper, and C. Wert (*Acta Met.*, 1961, **9**, May, 403–414) The interaction between interstitial N and C with dislocations in bcc iron has been examined by use of an elastic measurements. Use has been made of both the Snoek damping peak and the cold-work damping peak. It is suggested that methods which depend on use of either effect alone are insufficient for calculation of the strength of the interaction because such methods involve assumptions about the Cottrell atmosphere which apparently are unwarranted. A method is suggested whereby some of these assumptions can be avoided. By its use the binding energy between interstitial C and dislocations is estimated to be 0·5 eV per atom.

Dislocation motions and the yield strengths of solids J. J. Gilman (*ASTM, STP*, 1960, (283), June 27, 69–81) The most important factor in determining the yield or flow stress of a crystal is the plastic resistance of the crystal to dislocation motion. The core structures of dislocations are important in determining the plastic resistance to their motion. Internal stresses in crystals caused by impurities, radiation damage simply add to or subtract from the applied stress—thus causing a red reduction of the average dislocation for a given applied stress. Hardness data for several crystals are presented as a function of their elastic moduli. In view of these data it is believed that for nearly all crystals the plastic resistance to dislocation motion is what determines the macroscopic yield stress.

Concerning the question of the mechanism of relaxation of stresses in austenitic steels Ya. S. Gintsburg (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5**, 32–38).

Binding forces and statistical deformations in the lattice of alloyed ferrite V. A. Ilyina and V. K. Kritskaya ('*Problems of Metallography and the Physics of Metals*', Consultants Bureau, Inc., NY, 1959, 284–288) Six specimens were examined, Armco iron, and iron containing Mo, Co, Mn, Nb, and V. All the alloys were annealed at temp. corresponding to third order deformation and the characteristic temp. and statistical deformations were measured X-ray patterns being taken with Mo-radiations at two different temp. The measurements showed that, with the exception of V, all the alloyed elements increased the binding forces of the ferrite crystals. Mn, Nb, and Mo alloyed ferrite led to a significant increase in interatomic binding forces with decrease in amplitude of the thermal vibrations of the atoms; Co-atoms in the ferrite lattice also rendered the interatomic bond in solid solution crystals more stable. V, weakened the interatomic binding forces as compared with unalloyed ferrite crystals.—C.V.

Determination of binding energy in austenite lattices Y. V. Kornev ('*Problems in Metallography and the Physics of Metals*', Consultants Bureau, Inc., NY, 1959, 312–316) The experimentation is described and the data shows that C-reduces the binding forces in the austenite lattices; 5·8%C reduces the binding energy from 103·5 to 43·5 kcal/g. The experiments of the influence of C on the γ-Fe lattice confirm earlier work and are in agreement with the X-ray evidence which shows that the entry of C into the α–Fe lattice reduces the interatomic bonds in martensite lattices.—C.V.

Thermodynamic activity of carbon in austenite containing manganese and silicon V. M. Rozenberg and L. A. Shvartsman ('*Problems of Metallography and the physics of Metals*', Consultants Bureau, Inc., NY, 1959, 211–218) An analytical expression is obtained which gives the solubility of elements in a multicomponent solid solution; this is based upon known thermodynamic relationships derived from simple systems. An equation is proposed for the activity coefficient of C in austenite containing Mn and Si; this enables an approximate calculation of solubility of C in austenite at various concentrations to be arrived at; the temperature was 1000°C. Estimates are provided for values of heat of solution of C in Mn.

Device for scratching tensile test specimens H. Parchen (*DEW-Techn. Ber.*, 1961, **1**, April, 77–79).

On the ratio of transverse to axial strain and other tensile properties of a cold-rolled steel alloy A. Shelton (*J. Mech. Eng. Sci.*, 1961, **3**, March, 89–104) Tensile tests performed on a 0·4% carbon steel to determine the behaviour of the lateral/longitudinal strain ratio are reported and the results are presented in graphical form, showing the relationship between true tensile stress *v.* rolling reduction, and the corresponding point-to-point equivalent construction ratio *v.* rolling reduction. The experimental contraction ratio curve was computed from the strains in two transverse directions, and represents the uniform contractions which would be experienced by an isotropic bar. This curve is compared with a theoretical curve based on the assumption that a metal flows without change in its permanent volume. It is concluded that provided accurate values of the elastic constants are known, the equivalent isotropic contraction ratio for a given tensile strain may readily be compiled.—S.H.-S.

The ring method of testing materials in relaxation I. A. Oding, V. S. Ivanova, V. V. Burdukskii, and V. N. Geminov (**Ch. VII of 'Teoriva polzchesti i dlitel'noi prochnosti metallov' (The theory of creep and long-time strength of metals)* Moscow, Metallurgizdat, 1959, 331–367) The method of stress relaxation testing is mathematically described and discussed. Relaxation in metals using the ring testpiece is then investigated, followed by a study of stress distribution in the ring testpiece during the relaxation process, and concluding with a comparative study of the results of stress relaxation tests on ring and cylindrical testpieces.—S.H.-S.

The amplitude dependent damping of steel. Its causes and relation to tendency to brittle fracture G. Müller-Vogt, (*Arch. Eisenh.*, 1961, **32**, May, 323–330) [In German] Tests are described on specimens of four non-alloy or low-alloy steels of 0·04–0·69%C regarding damping behaviour at frequencies of 25 to 400 H_3 as a function of the amplitude and test temp. The cause of damping is the relation between damping and tendency to brittle fractures.

The most important methods of stress and strain measurement C. Rohrbach (*Materialprüfung.*, 1960, **2**, 468–472).

Stress relaxation in metals I. A. Oding, V. S. Ivanova, V. V. Burdukskii, and V. N. Geminov (*Chap. VIII of '*Teoriya polznechsti i dlitel'noi prochnosti metallov*' (*The theory of creep and long-time strength of metals*), Moscow, Metallurgizdat, 1959, 368–412) Theories of stress relaxation are mathematically presented and discussed. Stress relaxation criteria are then investigated and the possible mechanism of diffusional plastic flow is described. The influence of various factors on the stress relaxation criteria is then discussed and analyzed, with, in conclusion, an analysis of some investigations on Armco Iron.—S.H.-S.

Effect of prestrain at high temperatures on the retained ductility of steel K. Terazawa and T. Yoshida (*J. Soc. Naval Arch. Japan*, 1960, Dec., 419–434; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 552) Temp. and prestrain both affect ductility, high temp. prestraining reducing it markedly. Compressive prestrain scarcely reduces ductility at any temp.

Internal friction in lightly deformed pure iron wires J. D. Fast and M. B. Verrijp (*Philips Res. Rep.*, 1961, **16**, Feb., 51–56).

The definition and practical significance of linear thermal vectors of steels and welds H. M. Schnact (**Oerlikon, Buehrle & Cie, Service des Recherches de la Fabrique d'Electrodes*, Note No.601, 1960, Jan., pp.32) A review under the following headings: (A) The actual application of a construction in service. (B) Antitemperature and velogany. (C) Scientific definition of the tendency to brittleness in steels. (D) Rational testing techniques for steels. (E) Linear thermal vectors of a steel. (F) Facts and fiction in steel testing. Main characteristics of stress and strain states are tabulated and a basic diagram of a steel (after H. M. Schnadt) is appended.—S.H.-S.

Residual stress on the turned surface T.

Yokoyama and F. Hashimoto (*Seimitu Kikai*, 1960, **26**, Oct., 590–595; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 565).

Tensile properties of a single crystal of pure iron S. Dohi (*J. Sci. Hiroshima Univ.*, 1960, **23**, March, 395–406; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 472) A relation between stress and strain to be seen during the tensile straining at a constant rate was examined for single crystal plates of pure iron. There were two types of hardening; the linear and slow hardening for single crystal by single slip, and the parabolic and more rapid hardening for the one deformed by double slip. When a single crystal was deformed until a critical amount of straining by single slip, its tensile axis has 'overshot' the [001]–[011] symmetry line. The mechanism of tensile deformation for single crystals of pure iron, especially the mechanism causing the single slip or double slip, was explained on the basis of these experimental results.—C.F.C.

Experimental testing of standards for the twisting of mass-produced steel wire ropes P. D. Nesterov and B. D. Tikhovidov (*Stal'*, 1961, (5), 468–471).

Effect of stability of a 0·5%Cr–0·5%Mo steel on the rupture-time curve at 500° L. Bäcker, J. Bellot, M. Hugo, and E. Herzog (**International discussions on long time behaviour of high-temperature steel*, Düsseldorf, 1960, Paper 12).

Effect of melting procedure on mechanical properties of alloy A286 T. Hasegawa, O. Ochiai, and S. Yamashita (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1415–1418) The chemical composition of materials tested and their melting data are tabulated. The effect of melting procedure on short time tensile properties and on smooth and notch creep rupture strength at 650°C of Alloy A286 is described and illustrated.

Hydrogen attack on steels used in an oil refinery M. Hasegawa and S. Fujinaga (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1349–1352).

Development of high-temperature strain gauges J. W. Pitts and D. G. Moore (*NBS Monographs*, 1961, **26**, March, pp.20).

Some considerations on the yield phenomenon in mild steel S.-I. Karashima (*Proc. 2nd Japan Congress on Testing Materials*, 1959, 59–62) A yield mechanism is proposed, in which grain boundaries are reinforced and dislocations are anchored by solute atoms. The mechanism is based on the assumption that a considerable amount of plastic deformation takes place in the pre-yield stage (24 refs).

Formulae determining the flow stress of several steels S. Koncewicz (*Obr. Plas.*, 1960, **2**, (1), 73–86) The author evolves formulae which give the flow stress (K_r) as a function of steel composition, relative strain, temp., and deformation rate. The formulae were not checked by experiment but showed 10% deviation when compared with results obtained by P. M. Cook in 1957.

Studies on notch ductility of stainless clad steel. [Effect of clad ratio and clad arrangement on transition temperature] H. Kihara and T. Kusuda (*J. Soc. Naval Arch. Japan*, 1960, Dec., 375–383; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 594) [No abstract].

Practical observations on the numerical calculation of critical bending speeds (of shafts) P. M. Calderale (*Ing. Mecc.*, 1960, **9**, Dec., 17–21) [In Italian].

The behaviour of steel fibres subjected to bending stresses with special reference to middle strains G. Paolini (*Ing. Mecc.*, 1960, **9**, Dec., 33–40) [In Italian].

Photoelastic study of flat bars with a double notch on one edge subjected to pure bending Y. Murakami and T. Kawase (*Trans. Japan Soc. Mech. Eng.*, 1960, **26**, Oct., 1387–1395; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 473) Tests on bars with a circular or 60° notch and a U-notch at the base of the primary are evaluated.

Photoelastic study on flat bars with V-notches on both edges subjected to pure bending Y. Murakami and T. Kawabe (*Bull. Japan Soc. Mech. Engrs.*, 1960, **3**, Nov., 410–415; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 473) [No abstract].—C.F.C.

Resistance to deformation of carbon and nickel steels and alloys M. A. Zaikov (**Izvest. VUZ Chern. Met.*, 1958, (4), April, 103–116) A study is presented of a range of carbon steels with a carbon content of 0·12–1·2%, and of a number of nickel steels and iron–nickel alloys with nickel contents from 0·12 to 99·96%, the carbon content not exceeding 0·4%. The tests were made using a two-high 80 rolling mill, fitted with a gear-box permitting roll speed to be controlled from 8·8 to 1400 rev/min. Parallel tests were also made of the elongation and reduction of cylindrical test specimens at the same temperatures and deformation rates. A graphic-analytical method is used in the investigation in conjunction with the principle of minimum error.—S.H.-S.

Behaviour of compound steel cylinders subjected to internal pressure B. Crossland and D. J. Burns (*Proc. IME*, 1961, Aug., preprint, pp.15) The results of pressure tests on compound steel cylinders are compared with the theoretical pressure expansion curves, and discussed in conjunction with the literature available on the subject.—A.W.D.H.

Notch toughness of structural steels R. D. Stout and E. H. Kottcamp (*ASM Metals Eng. Quarterly*, 1961, **1**, (2), May, 58–69).

Fire cracking characteristics of Cr–Mo cast steel J. Watanabe (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1348–1349) Aspects dealt with include the relation between fire crack characteristics and Charpy impact value of Cr–Mo cast steel, the relation between fire-crack characteristics and carbon content of Cr–Mo cast steel and the effect of forging rate on the longitudinal and transversal fire-crack characteristics of Cr–Mo steel.

On the fractographic assessment of cast steel quality K. Stránský (*Slévárenství*, 1961, **9**, (5), 164–168) [In Czech] Examination of fracture surfaces is shown to facilitate rapid assessment of some important properties of the steels, e.g. impact strength, ductility, purity, etc. The discussion is related to results of extensive experimental work done by the author.—P.F.

How are we to get more from our steels G. O. H. Sjorgen (*Metallurgia*, 1961, **63**, May, 217–220).

Examination of tested rupture specimens of the 18 Cr 12 Ni 1 Nb steel J. D. Murray (*Brit. Electrical & Allied Ind. Res. Assoc.*, J/E/T 217, 24–31; International Discussion on Long-Time Performance of High-Temperature Steels, Düsseldorf, June 1960, Paper 26) Creep ductility is greatly affected by the stresses that are applied at the commencement of testing; this is specially applicable to austenitic steels where loading above the limit of proportionality brings about a type of warm working process; this has a marked effect on subsequent precipitations and hence the ductility is markedly affected. The practical applications of this are discussed.—C.V.

Comparison of rupture data on 2¼%Cr 1%Mo pipe and butt-welded pipe joints Stewart & Lloyds Ltd (*Brit. Electrical & Allied Ind. Res. Assoc.*, J/E/T 218, 50–51; International Discussion on Long-Time Performance of High-Temperature Steels, Düsseldorf, June 1960, Paper 20).

Low-temperature tensile-hardness correlations for SAE 4340 steel J. Nunes and F. R. Larson (*ASTM Bulletin*, 1960, (249), Oct., 25–29) Vickers hardness (DPH) and tensile strength (UTS) were studied on one heat of this steel. Tempered martensite, bainite, and pearlite of various strength levels were tested in a range from room temp. to −196°. These two variables, DPH and UTS are linear in respect to the reciprocal of the absolute temp. and the various strength levels formed a family of parallel lines; simple empirical equation could be derived from this to calculate approximate values for DPH and UTS within this temp. range. It was also shown that the SAE hardness-tensile strength correlation for room temp. is reasonably valid under the conditions studied.—C.V.

Effect of stress concentration on tensile strength of titanium and steel alloy sheet at various temperatures G. Sachs and J. G. Sessler (*ASTM STP*, 1960, (287), June 30, 123–135).

Stress/strain properties of cast iron and Poisson's ratio in tension and compression G. N. J. Gilbert (*BCIRA J.*, 1961, **9**, May, 347–363) In tension, the modulus of elasticity of cast iron decreases uniformly with increase of stress, but in compression this remains practically constant and independent of stress. Poisson's ratio remains constant at a value of 0·26 at relatively low compressive stresses and then increases slightly while at relatively high stresses, with plastic deformation of the matrix it exceeds 0·5 showing an increase in volume. With increase in longitudinal tensile stress there is a uniform decrease in this value. The peculiar stress/strain behaviour is explained by the assumption that the spaces occupied by the graphite are elongated in the direct of tensile stress. These voids result in a decrease of Poisson's ratio, with increase in stress. Since the voids show some recovery on unloading, the modulus of elasticity defining the total recoverable strain decreases with stress. This behaviour is further discussed but if it is assumed that the voids are created under stress, then the stress/strain properties under reversed stresses can be explained.—C.V.

Short time, elevated temperature, stress–strain behaviour of tensile, compressive and column members E. C. Bernett (*WADC Tech. Rep.*, 59–484; *PB* 161492, 1959, Dec., pp.131)

Current tests for evaluating fracture toughness of sheet metals at high strength levels J. E. Campbell and W. P. Achbach (*DMIC Rep.*, 124; *PB* 151081, 1960, Jan., pp.66).

The effect of a static tensile stress on the damping and ageing of α-iron H. Y. Seeman, M. Siol, and E. Detemple (*Annales Universitalis Saraviensis Naturwissen-schaffen-Scientia*, 1957, 300–309, reprint).

Ductility relationships in tensile testing E. B. Kula and F. R. Larson (*WAL–TR–111/25*, 1957, Oct., pp.30; from *Nuclear Sci. Abs.*, 1960, **14**, Dec. 31, 3329) An equation was developed relating elongation and reduction in area. This was compared to published relationships and to experimental results. Several factors of specimen geometry were discussed, such as gauge length and taper, which can influence elongation more than reduction in area. It was shown that errors of 15% in elongation may occur when using the standard ASTM tensile specimen.—C.F.C.

Static tension tests of compact bolted joints R. T. Foreman and J. L. Rumpf (*American Society of Civil Engineers, Structural Division, Journal*, 1960, **86**, June, 73–99; from *British Railways Monthly Rev. Techn. Lit.*, 1960, **10**, Dec. 8).

Ultimate strength of encased steel members subject to combined bending and axial load P. C. Varghese (*J. Inst. Eng. (India)*, 1961, **41**, Feb., 225–237).

Effect of gripping length and pickling treatment on the torsion properties of steel wire F. Bleilöb and H. Born (*Stahl Eisen*, 1961, **81**, March 16, 356–360).

Influence of steel-making variables on notch toughness J. H. Van der Veen (*Ship Structure Committee, SSC*–128, 1960, June 27, pp.33).

Comparative study of unalloyed steel welds with special reference to the relationship between the phosphorus content and the notch impact strength K. Born and O. E. Goerdt (*Arch. Eisenh.*, 1961, **32**, April, 225–236).

Low temperature impact strength of sintered steels L. d'A. Menezes (*Progress in Powder Metallurgy, Met. Powder Ind. Fed.*, 1960, **16**, 141–151) Ferrous metals such as C- and low-alloy constructional steels suddenly exhibit loss of toughness at a certain low temp. This 'transition temp.' may occur near 32°F or lower. However most of the non-ferrous metals are free from this characteristic, especially if the alloys are in a comparatively stable solid solution. On the other hand, unstable precipitation-hardening alloys are liable to show brittle behaviour at these low temp. Austenitic stainless steel (18–8) is virtually free from this effect and although this alloy is predominantly iron, it has no transition temp. down to −300°F. Steelmet 100, 101, 302, and 600 (as sintered) are examined for hardness (Rockwell B) at 70°, −40°, and −65°F and notched-bar Charpy impact values (ft/lb) are recorded for the same temp. A similar series for Steelmet 600, heat-treated, is also presented, while a table is given showing the toughness of eight

other steels (as rolled, normalized, and tempered) the required data being given.

Effect of neutron irradiation on Charpy V and drop weight test transition temperatures of various steels and weld metals J. R. Hawthorne and L. E. Steele (*ASTM, STP*, 1960, (286), June 29, 33–57).

Effect of carbon content on the notch properties of 43 XX vanadium-modified and 5%Cr sheet steels E. P. Klier (*ASTM, STP*, 1960, (287), June 30, 196–214) The notch properties of 43 XX V-modified steel containing 0·21, 0·30, 0·41, 0·50, and 0·60%C were measured for several tempered conditions at temp. from −320 to 85°F. 5%Cr steels containing 0·24 and 0·39%C heat-treated to hardnesses in the Rockwell hardness C40 to 50 range were likewise tested. In the 43 XX V-modified steels reduced C content improved notch toughness. In the 5%Cr steels the reverse effect was observed. The fracture characteristics of the steels were briefly discussed.

Cleavage fracture initiation in notched impact tests of mild steel J. W. Davies and A. A. Wells (*Nature*, 1961, **190**, April 29, 432) A modified Charpy test in which fracture is arrested immediately after initiation by the use of a rigid frame transmitting the remaining energy to balsa wood blocks confirms Cottrell's mechanism, here on the polycrystalline rather than the single crystal scale.

A new criterion to suggest some cold-working limits of steel: a comparison with data of ordinary tensile tests K. Takase (*Proc. 2nd Japan Congress on Testing Materials*, 1959, 130–132) A description is given of a method of obtaining flow curves by simulating the combined compression and tension as obtained in cold drawing processes. A strip specimen is indented on both sides by compression by cylinders, and then placed in tension to obtain the strength of the deformed portion.

On the structure of deformed F.C.C. metal single crystals A. Seeger and S. Mader (*Trans. Indian Inst. Met.*, 1960, **13**, 249–264).

The effect of deformation on the spec. gravity of iron K. Janas (*Hutnik*, 1961, **28**, (3), 113–120) An initial increase of density explained by the author as the result of elimination of micropores and segregations is followed by its decrease caused by new dislocations being produced. This process however is limited by interference of dislocations and it ends in the fracture of the sample.

Concerning the initial stage of the plastic deformation of industrial iron V. E. Kochnov and I. I. Zlochevskaya (*Izvest. AN Otdel. Tekhn. Met. i Toplivo*, 1961, (2), 60–63) On the extension of industrial iron (rimming steel 08 kp) even in the elastic region, to judge by the elongation diagram, grain sectors are observed which undergo plastic deformation. Deformation is localized initially in bands which widen on further deformation.—A.I.P.

A simple method of obtaining the flow curves of steel at room temperature M. Reihle (*Arch. Eisenh.*, 1961, **32**, May, 331–336) [In German].

An introduction to the problems of metal fatigue G. M. Astles (*Eng. Mat. Des.*, 1961, **4**, April, 212–216).

Some experiments on the fatigue strength of steel. (The effect of understressing and notch on fatigue life) M. Kawamoto and M. Seki (*J. Japan Soc. Test. Mat.*, 1960, **9**, Dec., 753–757; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961 **7**, Feb., 481) Relations between fatigue strength values which usually represent endurance limit and time strength (for finite life) are discussed. The curves often intersect. Notch factor is also considered.—C.F.-C.

Effect of surface roughness on the rolling fatigue life of bearing steels T. Utsumi and J. Okamoto (*J. Japan Soc. Lubr. Engrs.*, 1960, **5**, Sept., 291–295; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 480) [No abstract].

The fatigue strength of low-carbon steel for welded structures C. Schaub (*Radex Rund.*, 1961, June, 569–579) [In German] The results are given of pulsating fatigue tests on low-carbon steels of various chemical analyses; thermal and mechanical treatment respectively is prescribed for notched, welded and polished material; a general relation is found between the yield-point of the base metal and the fatigue strength.

A note on the fatigue properties of welded low alloy structural steels J. Y. Mann (*Austr. Dept. of Supply, Aeron. Res. Lab., Structural and Materials Technical Memorandum* 87, 1960, June, pp.9; from *Monthly Rev. Tech. Lit.*, 1961, **11**, April, 12) A survey has been made of published data on the fatigue properties of arc-welded low-alloy high-tensile structural steel plates. It is concluded that, from the fatigue viewpoint, these steels in the welded condition offer insignificant avdantages compared with welded mild steel, except possibly when the maximum stress of the cycle is high relative to the U.T.S. of the material.—C.F.C.

On the formation of fatigue cracks in compressed regions of welded bent girders O Puchner (*Zvaranie*, 1961, **10**, (5), 131–136) [In Czech].

Bending fatigue tests on large specimens under sea water corrosion S. Hara, J. Hoshino, and J. Arai (*J. Soc. Naval Arch. Japan*, 1960, July, 341–349; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 482) [No abstract].

Effect of cyclic speed and hardness on the change in residual stresses S. Taira and Y. Murakami (*J. Japan Soc. Test. Mat.*, 1960, **9**, Dec., 758–766; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 481) Quenched steel specimens were used and considerable effects from cyclic rate were revealed, residual stresses fading quicker at lower speeds. The fading can be predicted from that measured at any one cyclic rate, and a relation to hardness was also demonstrated.—C.F.C.

Plain bending fatigue strength of the welded joint. (2) Comparison of high-tensile steel with mild steel on the model joint of rolling stock H. Nakamura and S. Ueda (*Trans. Japan Soc. Mech. Engrs.*, 1960, **26**, Oct., 1361–1368; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 482) The high-tensile steel is often sensitive to notch effects and care in welding is necessary. Shot peening is especially effective. Annealing is not advisable for either steel but rough grinding restores fatigue strength. Crack propagation should be studied in the lateral direction of the test-piece in view of observations on toe cracks.—C.D.C.

Influence of rest in stress alternation on the fatigue of a 13 chromium steel at elevated temperature S. Taira, Y. Murakami, and R. Koterazawa (*J. Japan Soc. Test. Mat.*, 1960, **9**, Oct., 606–608; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 482) [No abstract].

Statistical distribution of the fatigue life of steel and the effect of heat-treatment on the dispersion of fatigue life M. Kawamoto, T. Nakagawa, and T. Takahashi (*J. Japan Soc. Test. Mat.*, 1960, **9**, Dec., 736–741; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 418) Large numbers of tests on 0·23%C steel are treated with respect to position of the specimen in the bar, higher and lower stress levels and effects of normalizing and annealing.

Fatigue tests of metals at ultrasonic frequency. (2) For materials having high endurance limits J. Awatani (*Trans. Japan. Soc. Mech. Engrs.*, 1960, **26**, Oct., 1382–1386; from *Japan. Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 482) In the ultrasonic fatigue testing machine previously reported (*Trans. JSME*, 1958, **24**, 480), it was necessary to use test pieces contracted at their mid-portion in order to induce higher stress there, and a graphical method was required to estimate the induced stress values. This paper presents an analysis of the vibration in a contracted test piece at resonance and some experimental results concerned. The stress can be estimated with ease and accuracy without a graphical complexity, if the oscillatory amplitude is known at one point on the piece. As an application, the S–N curves for bearing steel and copper are obtained.—C.F.C.

The effect of some design features on the fatigue life of bolts and nuts R. B. Heywood (*RAE Tech. Note Structures* 249, 1958, Sept., 1–15).

Theory of the non-linear influence of normal stress on fatigue under combined stresses J. J. Coleman and W. N. Findley (*DSIR TIDU* 6104, pp.31) It has been suggested that fatigue results from alternating shearing stress, and that the resistance of material to this action is influenced by the normal stress acting on the critical shear plane. In an earlier paper the influence of the normal stress was considered to be linear. The possible effect of anisotropy is also considered. A non-linear theory is developed and compared with other theories and with results of tests of SAE 4340 steel at a hardness of Rockwell C–25.—C.F.C.

Some quantitative information obtained from the examination of fatigue fracture surfaces D. A. Ryder (*RAE Tech. Note No. Met.* 288, 1958, Sept., 1–6) Mean spacing of striations is correlated with fatigue stress. In another series, crack propagation rates were obtained.

Electron microscopical study of the fatigue fracture of steel M. Kawamoto, S. Magari, and T. Nakagawa (*Proc. 2nd Japan Congress on Testing Materials*, 1959, 5–9) Electron microscope studies were made on the same point on the surface of 0·26%C steel specimens during fatigue tests, by stopping the machine at frequent intervals. The development of the fatigue crack is described.

The influence of metallurgical factors on fatigue limit and the statistical nature of fatigue fractures of plain carbon steel T. Yokobori (*Proc. 2nd Japan Congress on Testing Materials* 1959, 10–13) The ferritic grain size and inclusion counts on various carbon steels which had already been studied statistically were measured, and it is shown that ferritic grain size is decisive factor in determining fatigue limit and the statistical nature of the fatigue fracture of plain carbon steels (10 refs).

Concerning the determination of impact viscosity and cold shortness of manually and semiautomatically welded seams M. M. Kraichik and N. V. Pashkov (*Lit. Proizv.*, 1958, (11), 7–10) The values for impact viscosity and, in particular, for the cold-shortness threshold of a welded seam vary considerably, depending on the place from which the test specimen is cut. Impact test specimens for comparing the cold shortness of different seams should not be taken from the heat-affected zone, as the unaffected layer determines cold shortness.

Electron-microscopical investigation of deformation and fracture of high-alloy steels N. S. Alferova, A. I. Rizol', and V. P. Konovalov (*Issledovaniya po zharoprochnym splavam* Moscow, 1960, **6**, 300–307) Certain data are given of electron-microscopical investigation of structural changes during the cold plastic deformation of high-alloy tube grades of steel of the austenitic, ferritic, and semi-ferritic classes. It was possible to observe experimentally the non-uniformity in the course of plastic deformation in microvolumes.—A.I.P.

The weld-bead impact test for an appraisal of welded steels W. Rädeker (*Stahl Eisen*, 1961, **81**, Feb. 16, 228–234).

On the role of strain hardening in plastic range fatigue D. E. Gücer (*Trans. Met. Soc. AIME*, 1961, **221**, April, 415–416) Attention is drawn to the close relationship between the relative performances of steels under plastic range cycling and their strain hardening characteristics. Experimentation is devised using a cantilever beam of rectangular cross-section there being no lateral strain and the absolute value of strain undergone between a maximum state of tension and maximum state of compression is called Δ and it is shown that this value decreases rapidly with cycling due to strain hardening and the ensuing change in the bent beam profile. Δ attains an approximately stable value around the tenth cycle. Using two ASTM steels (A302 and A201) a series of curves are given for Δ_1, Δ_2, $\ldots \Delta_{10}$, the subscripts indicating the number of the cycle, and it is shown that since the exponent governs strain hardening at lower strain levels than the modulus, the relative values of both parameters also coincide with the change in η values and the relative performances of the two steels at different strain levels. These two relationships indicate the close relation between strain hardening and plastic range fatigue behaviour.—C.V.

Influence of carbon on the binding forces and on the static distortions in martensite crystals G. V. Kurdyumov, V. K. Kritskaya, and N. M. Nodia ('*Problems in Metallography and the Physics of Metals*', Consultants Bureau, Inc., NY, 1959, 317–321) The results obtained by measuring the intensity of reflections of the

phases with high indices confirm previous findings and show that the binding forces in the martensite lattice are weaker than in the α–Fe lattice. One of the causes may be the increase in the average distances between the Fe-atoms in the martensite lattice when the C is dissolved. The measurement of the static distortions in this lattice show that these distortions are quite considerable particularly when a high-C content is present. The high distortion of martensite crystals to plastic deformation cannot be attributed to the binding forces in the lattices for these are not only not greater than in the α–Fe crystals but are in fact substantially smaller. This is discussed.

On the plastic properties of modified steel, Kh25N20, in the cast state V. E. Neimark and Y. B. Gurevich ('*Problems of Metallography and the Physics of Metals*', Consultants Bureau, Inc., NY, 1959, 439–449) If the Cr-concentration is ⩾24–25% this steel has an austenite structure; at a higher concentration the σ-phase is found in the cast steel the proportion of this phase depending on the Ni present; this phase separates out in this steel and also in Kh18N9 but increase in Ni by 2–3% prevents this separation in austenite. The macro- and microstructures of these steels have been investigated and the effect of additions of Ti, Nb, Al, and Mo studied. Data is also given of the resilience of these steels with the indicated additions in various concentrations over a wide temp. range.—C.V.

Deformability of cast steel type Kh25N20 Y. B. Gurevich and V. E. Neimark ('*Problems of Metallography and the Physics of Metals*', Consultants Bureau, Inc., NY, 1959, 450–455) Under indicated conditions of working, this steel, with columnar macrostructure, possesses a reasonably high plasticity both in the hot/and cold state; the optimum temp. for hot rolling is 1150°. The cast metal must be subjected to a diffusion anneal at 1250° to remove the dendrite liquation and destroy the σ-phase; this is followed by water cooling to prevent carbide separation on the grain boundaries. The allowable reduction in hot rolling is 60–65% but when applied to small parts this may be increased to 75%. In lengthwise rolling with non-uniform reduction of section, in the rolling of tubes (exclusive of oblique rolling) not more than a 45–50% reduction should be employed. The question of cold rolling is also discussed.

Fatigue strength of steel with low carbon content for welded structures C. Schaub (*Jernkont. Ann.*, 1961, **145**, (2), 88–108).

Thermal stress and thermal stress fatigue L. F. Coffin jun. (*Proc. Mat. Eng. Design for High Temperatures*, 1959, 187–232).

Fatigue of structural metals under random loading A. M. Freudenthal (*ASTM, STP*, 1960, (284), June 28, 26–36) The fatigue life under randomly varying stress amplitudes is discussed in terms of the interaction between infrequent high stress amplitudes and the dominant low stress amplitudes. An 'interaction factor' is developed with the aid of which the validity of a pseudo linear rule of cumulative damage is demonstrated for structural aluminium. The relation established between the distributions of fatigue lives under randomly varying and under constant stress amplitudes as well as between the form of the distribution of fatigue lives and the risk of fatigue failure.

Conventional, resonance and acoustic fatigue of structural materials at elevated temperatures B. J. Lazan (*Proc. Mat. Eng. Design for High Temperatures*, 1959, 155–186).

Prediction of acoustic fatigue life H. C. Schjelderup (*ASTM, STP*, 1960, (284), June 28, 19–25) Current procedures used by the airframe industry for predicting fatigue life of structures loaded by high energy acoustic noise are reviewed. Deficiencies in the methods are discussed and future work is suggested. The need for spectrum-type fatigue tests is emphasized.

Experimental techniques and equipment for acoustical fatigue research and development S. M. Forney (*ASTM, STP*, 1960, (284), June 28, 54–65).

Some technological influences on the fatigue strength of steels M. Hempel (*Draht*, 1960, **11**, Sept., 589–600).

The effect of hardness and grain size on the thermal fatigue of heat-resisting steel S. I. Kutkovskii (*Isseldovaniya po zharoprochnym splavam*, Moscow, 1959, **5**, 187–191) Different grain sizes have practically no effect on the resistance to thermal fatigue of austenitic heat-resisting steel. Zones of a uniform large grain are more sensitive to thermal fatigue than zones of normal or different grain sizes. Sensitivity to thermal fatigue increases with increased hardness.—A.I.P.

Fatigue strength of marine shafting G. P. Smedley and B. K. Batten (*NE Coast Inst. Eng. Shipbuilders*, Preprint, 1961, 293–320).

A study of size effect on fatigue strength of steel H. Ouchida (*Proc. 2nd Japan. Congress Testing Materials*, 1959, 14–18) As a result of the tests described it is concluded that (1) the size effect of plain and notched specimens is large with diameters less than 20 mm, but comparatively small at larger diameters up to 100 mm, (2) the endurance limit increases about 10% as the diameter increases from 10 to 100 mm, (3) fatigue strength reduction factor of 100 mm dia. specimens in low and medium plain C steel is much less than the stress concentration factor, but these factors are nearly equal for Ni–Mo steel.

Fatigue strength of notched steel specimens subjected to a reversed torsion T. Isibasi and T. Matake (*Proc. 2nd Japan Congress on Testing Materials*, 1959, 19–21) Relationships between the threshold stress for developing a crack at the root of a notch and the stress at fracture are examined for specimens of a 0·38%C steel subjected to reversed torsion.

The effects of repeated stresses and number of cycles on the longitudinal residual stress of drawn wires H. Nakamura, M. Kakuzen, and T. Nishihara (*Proc. 2nd Japan Congress on Testing Materials*, 1959, 34–37) A description of tests made on a specially designed machine to study these effects across the section of cold drawn carbon steel wire.

Studies on the fatigue resistance of a crankshaft (1) E.-I. Sato, T. Nakano, and S. Yamatoto (*Proc. 2nd Japan Congress on Testing Materials*, 1959, 40–43).

The fatigue of induction-hardened coiled springs H. Nakamura, T. Saga, and S. Asakawa (*Proc. 2nd Japan. Congress on Testing Materials*, 1959, 38–39).

The problem of cumulative fatigue damage in sheet T. R. G. Williams, D. H. Hughes (*Sheet Metal Ind.*, 1960, **37**, Sept., 653–659) The authors review developments in the estimation of cumulative fatigue damage and conclude that these methods require special data and fail to make use of the S/N curve. For sonic excitation it is concluded that the most significant parameter is the cumulative variation in stress amplitude.—A.H.M.

The use of the 'Isodamage' curves in the representation of damage phenomena with particular reference to fatigue L. Locati (*Ing. Mecc.*, 1960, **9**, Dec., 41–47) [In Italian] This article considers the phenomena originating from damaging action, occurring in a given period (wear, fatigue, etc.). If the curve representing the end of the phenomena can be interpreted as unitary damage other isodamage curves can be plotted alongside the former, each corresponding to partial damage. This is useful in the programming tests in which the damaging action is variable. An immediate check can be made whether the damage has a cumulative property character (Miner's theory on fatigue) or whether overload, training, or breaking in phenomena are present.

Deflection of a Wohler test piece during fatigue cycling D. H. Hughes and T. R. G. Williams (*Engineer*, 1961, **211**, March 31, 498–499) Apparatus was devised to measure the deflection of the free end of a Wohler test-piece, and thus to distinguish between the primary, secondary, and tertiary stages of fatigue life. The effect of fatiguing on the fracture transition temp. was also investigated.

Effect of lubricants on rolling fatigue life of ball and roller bearing steels M. Kuroda (*J. Japan Soc. Lubr. Engrs.*, 1960, **5**, Sept., 283–290; from *Japan Sci. Rev, Mech. Elect. Eng.*, 1961, **7**, Feb., 480) [No abstract].—C.F.C.

Relation between thermal fatigue and cyclic strain fatigue at elevated temperature S. Taira, R. Koterazawa, and M. Ohnami (*J. Japan Soc. Test. Mat.*, 1960, **9**, Oct., 636–641 from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 476) Analysis in terms of a steady equivalent temp. is carried out and the conclusions are verified on an 18–8 stainless steel.

Study on the effect of overload using the decreasing load method U. Rossetti and G. Luboz (*Ing. Mecc.*, 1960, **9**, December, 49–54) [In Italian] This article describes rotating bending tests carried out to study the overstressing effect on a chrome–nickel steel. The fatigue test starts with a load above the limit of endurance with progressive reduction of stress. The results obtained did not reveal any noticeable overstressing effect—in fact the effect is within range one.

On the relation between the fatigue rupture and the crystal grain size of steel M. Isobe and S. Isobe (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1352–1354) A table shows the heat-treatment and mechanical properties of steels according to the austenite grain number. Aspects dealt with include relation between the austenite grain size number and the repeated-impact fatigue of SCM21 steel, the relation between the tempering temp. and the repeated impact fatigue of SK4 and SMC steels.

Testing of wire rope E. A. Franke (*Erie*, 1960, Dec., 242–244).

Fatigue strength of mild steel under cathodic protection in sea water Y. Minami and H. Takada (*Proc. 2nd Japan Congress on Testing Materials*, 1959, 123–125) The influence of electrode potential on the fatigue strength of mild steel using impressed currents is examined.

Fatigue Bauschinger effect M. Kawamoto, H. Tanaka, and H. Kisimoto (*Trans. Japan Soc. Mech. Engrs.*, 1960, **26**, Oct., 1333–1339; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 473) A Bauschinger effect can be recognized during pulsating stresses at a stress level slightly below yielding.

Studies on the torsional fatigue of steel wires. (3). Torsional fatigue limit of cold drawn steel wire with low carbon content T. Ueda and M. Tanaka (*J. Japan Soc. Test. Mat.*, 1960, **9**, Oct., 624–628; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 483) [No abstract].

Investigations on the fatigue properties of steel wire. (4). Effect of the local martensite formation by the impact loading friction on the fatigue strength under rotary bending of cold drawn steel wire T. Ueda and K. Asakura (*J. Japan Soc. Test. Mat.*, 1960, **9**, Oct., 609–618; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 482) [No abstract].—C.F.C.

New creep tester United Steel Co. Ltd (*Iron Steel*, 1960, **33**, Dec., 606).

Dynamic creep characteristics of low carbon steel at elevated temperatures S. Taira, K. Tanaka and R. Koterazawa (*Proc. 2nd Japan Congress on Testing Materials*, 1959, 55–58) Dynamic creep and rupture tests were made on low C steel at 450°C. It is shown that alternating stress superimposed on static stress considerably increases the creep strain. Concordant results were obtained by calculation.

Creep of low carbon steel under combined variation of stress and temperature S. Taira, K. Tanaka, and M. Ohnami (*Proc. 2nd Japan Congress on Testing Materials*, 1959, 50–54) Two sets of creep tests were made on a plain 0·15% C steel, i.e. under fixed applied stress and temp. variation, and under simultaneous variation of stress and temp. The results are discussed.

Creep in semi-annular plates P. Ya. Boguslavskii (**Teploenergetika* (*Moscow*), 1958, (2), 56–61).

Relaxation and creep I. A. Oding, V. S. Ivanova, V. V. Burdukskii, and V. N. Geminov (*Chap. IX of '*Teoriya polzuchesti i dlitel'noi prochnosti metallov.*' (*The theory of creep and long-time strength of metals*), Moscow, Metallurgizdat, 1959, 413–438) The connexion between creep and stress relaxation phenomena in metals is discussed. The relationship between the criteria of creep and stress relaxation is then investigated, and the possibility of damage to metals is reviewed and analyzed.

Some creep properties of an 18/8 stainless steel at room temperature, 250°C, 400°C and 550°C L. W. Larke and R. A. Whittaker (*RAE Tech. Note No. Met.*240, 1956, March, 1–8) Tests with 0·1% and 1·0% prior strain at

room temp. were made. In all cases a rapid increase in strain followed by a relatively small creep rate was found.

Creep properties of heat engine materials I. Mester (*Koh. Lapok*, 1961, **94,** May, 211–218) The author reviews the various interpretations and evaluations of creep-test results, and emphasizes the importance of the results of long tests as compared with those of short ones.

Creep-rupture strength of 28Cr–15Ni stainless steels T. Fujita and T. Sasakura (*Tetsu-to-Hagane*, 1960, **46,** Sept., 1414–1416).

Influence of cooling rate, heat treatment and solidification conditions on room temperature properties and on creep behaviour of a cast steel with 1%Cr, 0·9%Mo and 0·3%V K. Gut and H. Lüling (**International Discussion on 'Long time behaviour of high temperature steels'*, Düsseldorf, 1960, Paper No.17).

Deformation properties J. D. Lubahn (*Proc. Mat. Eng. Design for High temperatures*, 1959, 41–80) A detailed review in which tensile test, the creep test, anelastic creep, rate sensitivity, and strain hardening, the mechanical equation of state, strain ageing, and recovery, secondary hardening, stress-state effects, universal stress-strain relationship, and combined stress at elevated temperature are discussed. The limitations of the plasticity laws and the procedure for the solving of problems are also dealt with.—C.V.

The tasks and the composition of a creep testing laboratory H. Reiner and U. Schiferstein (*Brit. Electric & Allied Ind. Res. Assoc.*, J/E/T 216, 1960, Oct., 37–52; International Discussion on Long-Time Performance of High Temperature Steels, Düsseldorf, June 1960, Paper 35).

Resistance to creep deformation and fracture F. Garofalo (*ASTM, STP*, 1960, (283), June 27, 82–98) Various techniques employed in studying the factors controlling resistance to creep and creep rupture are reviewed and discussed. Primary and complex modes of deformation have been identified metallographically. Measurements of grain distortions well below the specimen surface indicate that grain boundary shearing may be more important than is indicated by surface studies. The end of secondary creep may depend in some cases on grain boundary shearing and hence may be affected by precipitation in the boundaries. It is shown that rupture life is proportional to the time at the end of secondary creep. Results obtained on stainless steel suggest that for this material crack growth does not depend to any extent on vacancy condensation. In this material the intercrystalline cracks are predominantly of the wedge type.

Basic aspects and physical theories of creep of metals J. E. Dorn (*Proc. Mat. Eng. Design for high temperatures*, 1959, 1–40) A very detailed review.—C.V.

A contribution to the practical application of creep values. (A) relation between bar and tube material. (B) Circular weld seams on tube material P. Bettzieche (*Brit. Electric & Allied Ind. Res. Assoc.*, J/E/T 218, 38–49; International Discussion on Long-Time Performance of High Temperature Steels, Düsseldorf, June 1960, Paper 19) A general discussion: the data provided suggest that composite test pieces, cut transversely to the weld seams, are highly unsuitable for the evaluation of welds in tubular material; if the creep strength of the welded connections were actually 18–30% lower than that of the non-welded parent metal, this would most certainly be reflected in the creep tests on tubes. This was not found. Therefore welded tubes should be tested under internal pressure. This argument is further extended.—C.V.

The effect of superimposed fatigue stress on creep characteristics A. H. Meleka (*Brit. Electric & Allied Ind. Res. Assoc.*, J/E/T 216, 1960, Oct., 25–31; International Discussion on Long-Time Performance of High Temperature Steels, Düsseldorf, June 1960, Paper 33) Earlier investigations are summarized. The behaviour of pure metals under these conditions is outlined together with a structural model which adequately accounts for this behaviour, and future lines of study are outlined. Fatigue stress produces an immediate and large increase in the creep rate which is generally greater than the original static creep rate; when the fatigue stress is removed, the metal exhibits a decreased creep rate to a value even lower than the original static one. This is quite general, occurring in Fe, Cu, Zn, and Pb, and was also observed in single crystal specimens. The same effects are present even if the maximum stress in the presence of the fatigue stress does not exceed the original creep stress.

The role of interface surfaces in the long-time fracture of metals I. A. Oding, V. S. Ivanova, and Yu. P. Liberov (*Issledovaniya po zharoprochnym splavam*, 1959, **4,** 3–12) The most probable mechanism of long-time fracture of metals is the process of formation and precipitation of vacancies. During service, separation and coagulation of secondary phases can also lead to a significant weakening of the corresponding regions of the primary solid solution and grain boundaries (20 refs).

Investigation of the effect of heat treatment on the creep-rupture properties of the 18 Cr–8 Ni alloy W. E. Leyda (*Brit. Electrical & Allied Ind. Res. Assoc.*, J/E/T 217, 2–14; International Discussion on Long-Time Performance of High Temperature Steels, Düsseldorf, June 1960, Paper 24) To insure the stipulated yield strength and tensile strength at room temp., the C-content should be a minimum of 0·04% and to ensure satisfactory creep-rupture properties, mill-annealing must be carried out at a minimum of 2000°F. If post-fabrication heat-treatment is required due to welding or cold bonding, annealing should be done at a minimum temp. of 2000°F. To obtain the maximum creep-rupture strength for a given annealing temp., the material must be rapidly cooled.—C.V.

Creep and creep-rupture relationships in an austenitic stainless steel F. Garofalo, R. W. Whitmore, W. F. Domis, and F. von Gemmingen (*Trans. Met. Soc. AIME*, 1961, **221,** April, 310–319) Constant-load creep-rupture tests were made on a Type 316 18Cr–8Ni–2Mo austenitic stainless steel at 1100, 1300, and 1500°F. At any stress level, at the temp. used, a measurable amount of scatter is found in the minimum creep rate and rupture life; this is particularly true at 1100°. Certain empirical relationships are discussed and it was also found that secondary creep strain depended on the type of grain boundary precipitate since this affects grain boundary migration. This also is examined in some detail.—C.V.

Investigation on the relation between elongation and crack formation in the creep test on a chrome–nickel–molybdenum steel K. G. Olsen (*Brit. Electric & Allied Ind. Res. Assoc.*, J/E/T 216, 1960, Oct., 2–6; International Discussion on Long-Time Performance of High Temperature Steels, Düsseldorf, June 1960, Paper 30) In long time stressing of steel at high temp., fractures of various kinds occur and under the action of static continuous stress at high temp. a steel can become notch sensitive. This implies that under a nominal stress a notched specimen will fracture earlier than a smooth one. This is discussed. Using the indicated steel it has been shown that a close relationship exists between reduced impact toughness and the development of cracks or cavities in the former austenite grain boundaries. On the other hand it is not possible to observe these in a specimen which had been stressed at the temperature in question for such a short time that no reduction in notch impact toughness developed. The steel was 0·28%C, 0·26%Si, 0·46%Mn, 0·017%P, 0·007,%S 0·62%Cr, 0·4%Mo, 3·08%Ni; this was killed with 750 g/ton Al. The tests are described and elongation curves and curves for the various crack ratings are shown. The method is comparatively simple and appears to be of value when using a steel as effectively and safely as possible for long-term stress in heat.—C.V.

Investigation of the creep rate of a chrome–molybdenum steel in various heat treatments K. G. Olsson (*Brit. Electrical & Allied Ind. Assoc.*, J/E/T 218, 16–22; International Discussion on Long-Time Performance of High Temperature Steels, Düsseldorf, June 1960, Paper 15) The creep during 3000 h serves as a guide to the high temp. stability of low-alloy steels; Cr–Mo steels were used after different austenitic conversions with various temperings (500°, stress 12 kg/mm^2, creep rate $\sim$1·10^{-5}%/h, 1000h load time for normalized state, and for a state tempered to 700°.) Austenite conversion to martensite by water cooling gave a considerably higher creep rate than isothermal austenite conversion to ferrite–pearlite at 700° or to an intermediate structure at 425° or continuous austenite conversion to a mainly intermediate structure by air cooling. These last three conversions gave the same creep development after the fundamental tempering for 26 h at 550°. It is pointed out that the test periods are too short to give definite pronouncements but at least they are indicative.

The creep and rupture properties of 2¼% chromium 1% molybdenum steel J. D. Murray (*Brit. Electrical & Allied Ind. Res. Assoc.*, J/E/T 215, 11–20; International Discussion on Long-Time performance of High Temperature Steels, Düsseldorf, June 1960, Paper 2) A report is given relating to 32 heats of steel with the range 0·082–0·17%C, 0·038–0·69%Mn, 0·13–0·38%Si, 2·06–2·35%Cr, and 0·87–1·07%Mo. Chemical analysis, heat-treatment, stress to rupture, creep properties, etc., are presented in tabular for graphic form. German and British data are compared for 10000 and 100000 h. The casts were in the form, 17 as bar, 4 as tube, and 11 as pipe.—C.V.

Results of stress to rupture creep tests on steels alloyed with 1%Cr–0·5%Mo: 2·25%Cr–1%Mo and 0·5%Mo–0·25%V W. J. Kaufman (*Brit. Electric & Allied Ind. Res. Assoc.*, J/E/T 215, 19–21; International Discussion on Long-Time performance of High Temperature Steels, Düsseldorf, June 1960, Paper 3) This work was carried out in the laboratories of Koninklijke Machinefabriek Geb. Stork & Co. N.V., Hengelo; the time to rupture and rupture elongation of some steels at 550° and 600° are reported in a series of tables and graphs. Photomicrographs are also provided.—C.V.

A note on extrapolation J. Glen (*Brit. Electric & Allied Ind. Res. Assoc.*, J/E/T 219, 2–8; International Discussion on Long-Time Performance of High Temperature Steels, Düsseldorf, June 1960, Paper 8).

Changes in certain physical properties of metals in the creep process at high temperatures N. A. Oding and L. K. Gordienko (*Issledovaniya po zharoprochnym splavam*, Moscow, 1960, **6,** 3–16) Regularities were studied. A link was found between properties studied and a structural factor; presence of incompleteness in the crystal lattice of materials. The kinetics of the course of the creep process has a first-stage effect on the level of physical properties of metals (14 refs).—A.I.P.

Effect of varying condition of loading on the long-time strength of steel I. A. Oding and V. V. Buroinskii (*Issledovaniya po zharoprochnym splavam*, Moscow, 1960, **6,** 77–88) Normally the criterion of long-time strength is obtained as a result of testing samples under conditions of constant active loading, while actual machine parts usually operate under varying loads. A relationship is suggested for the build-up of defects in metal during service in creep conditions, which would make it possible to consider the effect of varying conditions of loading on criteria of long-time strength. A criterion is suggested for assessing the course of the accumulation by metal of defects in service under creep conditions. The relationship proposed has been confirmed experimentally on several grades of austenitic heat-resisting steel (16 refs).—A.I.P.

Long-time strength of steam superheater pipes made from austenitic steel with a complex stressed state in a steam medium I. N. Laguntsov and V. K. Svyatoslavov (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5,** 107–112) Long-time strength of test-pieces made from austenitic heat-resisting steel grade EI695 tested in a steam medium and in a complex stressed state was much lower than that of test-pieces of the same steel under tension in air.—A.I.P.

The effect of temperature drops on the long-time strength of steel 12KhMF I. I. Laguntsov and L. I. Fedotova (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5,** 113–118) Temporary temp. drops cause a sharp drop in the long-time strength of steel 12KhMF. A temp.-time relationship can be used to assess the effect of temp. drops. Details of how this can be done are given.—A.I.P.

Conclusions drawn from long-time creep tests for low alloy steels W. Stauffer and A. Keller (*Brit. Electric & Allied Ind. Res. Assoc.*, J/E/T 215, 22–30; International Discussion on Long-Time Performance of High Temperature Steels, Düsseldorf, June 1960, Paper 4) Longer creep tests frequently require corrections in the 100000 h creep strength; these are mostly in a downward direction. The results of these tests on materials and groups of materials can be most explicitly expressed by scatter bands; only the longest possible test periods should however be used. A number of scatter bands with a width ±25% are presented on the basis of the present work and it was found that often the rupture strength lay above this band although it was also noted that most of this group were associated with excessive alloy content and excessive hardening. It was noted that this effect appeared to wear off after long periods and had disappeared completely, or almost completely after 100000 h. The creep values quoted by manufacturers are criticized; it is suggested that their values should not be stated as an average, but as a minimum creep value.—C.V.

Creep design—Application to gas turbines S. S. Manson (*Proc. Mat. Eng. Design for High Temperatures*, 1959, 369–418).

Strength of thick-walled cylindrical vessel under internal pressure for three steels J. Marin and Tu-lung Weng (*Weld. Res. Council, Bull. Series*, 1961, (67), pp.13).

Increasing the service life of skip hoist ropes G. I. Shandrenko and G. A. Pashkov (*Metallurg*, 1960, (5), 11–14) [In Russian].

Vibration hazards and their prevention in buildings Y. Otsuki (*Proc. of the Symposium on the Failure and Defects of Bridges and Structures, Japan Society for the Promotion of Science*, 1958, Dec., 33–40) [In English] A review.

Steel and aluminium alloy hatchway beams tested at Glengarnock M. N. Parker, J. A. Ross, and K. V. Taylor (*Trans. Inst. Eng. Ship. Scotland*, 1959–60, **103**, 11–53).

Defects in railway bridges and their remedies K. Tomonaga (*Proc. of the Symposium on the Failure and Defects of Bridges and Structures. Japan Society for the Promotion of Science*, 1958, Dec., 8–32).

Hardenability of tool steels O. Mülders and R. Meyer-Rhotert (*DEW-Techn. Ber.*, 1961, **1**, April, 41–48) Attempts were made to correlate the hardenability of tool steels with data collected in transformation, end-quenching, and tempering tests of cold-, hot-, and highly-workable steels, indicating that the correlation must be relied upon within certain limits only. A minimal hardness is suggested in the case of cold work steels while the critical dia. in the pearlite range is suggested as a suitable criterion for the hot- and quick-workable steels (18 refs).—M.L.

On the nature of hardness of tempered steel G. V. Kurdyumov ('*Problems of Metallography and the Physics of Metals*', Consultants Bureau, Inc., NY, 1959, 221–231) A detailed review (28 refs).—C.V.

Concerning the effect of chromium, molybdenum, and tungsten on the time and temperature relationship on the hot hardness of ferrite I. F. Zudin and O. A. Bannykh (*Issledovaniya po zharoprochnym splavam*, 1959, **4**, 266–272) Quantitative relationships have been found for the effect of Cr, Mo, and W in concentrations of about 0·9-at% on the creep of iron during a test for long-time hot hardness.—A.I.P.

The effect of complex alloying with vanadium, chromium, and tungsten on the kinetics of the change in hardness when annealing cold-deformed ferrite O. A. Bannykh and I. F. Zudin (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5**, 68–74) Six alloys were tested. The method is described and results are given. For each alloy, hardness after deformation is compared with hardness after annealing for different periods (9 refs).—A.I.P.

Micro-hardness of phosphorus eutectics in grey cast iron M. Dubowicki and K. Sekowski (*Prz. Odlew.*, 1961, **11**, (4), 101–104) Out of four modifications of phosphorus eutectics, pseudo-binary eutectic Fe_3P–austenite or ferrite–graphite, binary eutectic Fe_3P–Fe_3C with very fine cementite, ternary eutectic cementite in large needles and ternary eutectic mixed with the supereutectoid cementite, the hardest was the binary eutectic Fe_3P–Fe_3C, the softest the pseudo-binary eutectic.

Ageing of certain heat-resisting alloys on a iron–nickel–chromium base I. A. Bil'dzyukevich, G. V. Kurdyumov, and L. G. Khandros (*Issledovaniya po zharoprochnym splavam*, 1959, **4**, 208–213) Alloy EI 437 and alloys of that type, in which Ni is partly replaced by iron, have a similar ageing character. An increase in the hardness value is observed after tempering quenched test-pieces in the temp. range 600–900°. Ageing is accompanied by separation of the α'-phase, which has the same crystal lattice as the primary solid solution. Many other facts were established.—A.I.P.

The influence of ageing treatment on the temperature dependence of the electric resistance in the Alnico-5 magnet T. Fujiwara and T. Kato (*J. Phys. Soc. Japan*, 1960, **15**, Sept., 1705).

Segregations of solute atoms during strain ageing T. Mura, E. A. Lautenschlager, and J. O. Brittain (*Acta Met.*, 1961, **9**, May, 453–458) A theory and verifying experimental data are presented to explain strain ageing of iron and steel under several ageing strains, stresses, and temperatures. Both the theory and the experimental results differ from Harper's, Bullough and Newman's, and Ham's formulas.

Acceleration of the ageing cycles of the heat-resisting austenitic steel EI481 K. I. Terekhov (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5**, 42–49) New more effective ageing conditions for forgings of turbine discs, power rings, and other parts made from heat-resisting austenitic steel EI481 have reduced the time of isothermal holding when ageing from 28–36 to 10–18 h.—A.I.P.

Concerning one contradiction in the cold-shortness theory N. N. Davidenkov (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **4**, 13–20) There are two contradictory viewpoints on the mechanical nature of brittle fracture. An hypothesis is put forward which takes in both. According to it two conditions must be met simultaneously: a certain small value of tangential stresses (displacement threshhold), which ensures the appearance of the first microcrack, and a given value of normal elongation stresses (brittle strength) necessary for the propagation of the brittle crack (apart from the natural requirement that the normal stress, corresponding to brittle strength, is below the yield point, which is also included in normal stresses) (15 refs).—A.I.P.

Low temperature brittle fracture J. D. Lubahn (*Proc. Mat. Eng. Design for High Temperatures*, 1959, 81–153).

A new answer for brittle failure problem J. G. Parr (*Can. Metalw.*, 1961, **24**, Feb., 37–40) The argument is advanced that the brittle/ductile transition can be rationalized on the basis of dislocation theory and with the use of fairly well understood parameters. The transition is seen to occur in the absence of notches and residual stresses, but the effect of these can be surmised from the theory. Where residual stresses are present, dislocation movement (and hence ductile behaviour) is made difficult; such stresses themselves can be regarded as being associated with dislocations and the term r (the resistance of the metal against the movement of a dislocation) becomes large and brittle fracture is encouraged. The effect of notch is not so simple to explain; when yielding commences at the root of the notch, the metal at a distance constrains the propagation of the dislocations that are released and since these cannot propagate away from the notch, a very high stress concentration is built up at the root of the notch and it has been shown that this causes a threefold increase in the acting tensile forces. These aspects are further discussed with special reference to the determination of transition temp. and the reliability of the values obtained.—C.V.

Brittle fracture strength of metals E. T. Wessel (*ASTM, STP*, 1960, (283), June 27, 99–117) The brittle fracture strength of a metal is described and discussed. Aspects dealt with are, the mechanism of fracture initiation; the nature of the fracture strength of metals in simple tension as related to their resistance to plastic flow; the effect of various test conditions on fracture strength; the behaviour of several metals under severe testing; and relationship of fracture behaviour to conventional yield strength. It is shown that while the theoretical strength of a metal is quite high the presence of defects or imperfections results in failure at relatively low applied stresses.

Hydrogen embrittlement in terms of modern theory of fracture P. A. Blanchard and A. R. Troiano (*WADC Techn. Rep.* 59–444, *PB* 161531, 1959, Aug., pp.26) An attempt is made to apply Cottrell's theory of brittle fracture to H_2 embrittlement, a tentative explanation of the fact that so far only transitional elements have been embrittled by H_2, and the influence of the composition of Ni-base alloys on their susceptibility to H_2 embrittlement is discussed with examples (18 refs).

An investigation of the hydrogen brittleness of low-alloy steels K. V. Popov, V. A. Yagunova, and N. A. Khvorostukhina (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5**, 119–125) A hydrogen content in quantities of only 0·0006% or less, leads to a sharp drop in ductility under static tension, which in certain cases is accompanied by an increase in strength. A reduction in the ductility of steel containing H_2 can be the result of (a) the appearance of H_2 pressure in structural microdefects, and (b) surface-active effect of atomic H. In addition, a certain increase in brittleness can be observed as a result of the splitting of the surface layers of the testpiece under cathodic polarization (12 refs).—A.I.P.

On the mechanism of crack initiation in embrittlement by liquid metals H. Nichols and W. Rostoker (*Acta Met.*, 1961, **9**, May, 504–509).

Minimum toughness requirements for high-strength sheet steel J. A. Kies and H. L. Smith (*PB* 161786; *Interim Rept.*, 1960, Oct., pp.21; *NRL rept.* 5521; from *US Res. Rep.*, 1961, **35**, Jan. 13, 200) Calculations assuming a through crack are made and length of crack is taken into account. A quality factor for steel is suggested.—C.F.C.

Brittle fracture of pressure containers and methods of prevention A. A. Wells (*Rev. Soudure*, 1960, **16**, (4), 328–333) [In French].

Selection of steels for the avoidance of brittle failure K. Winterton (*Can. Mines, Inf. Circ.* 120, 1960, July, pp.44).

The lower critical stress for delayed failure E. A. Steigerwald, F. W. Schaller, and A. R. Troiano (*WADC Techn. Rep.* 59–445; *PB* 161532, 1959, Aug., pp.30) The lower critical stress is defined as the min. stress required to produce the critical amount of H_2 segregation for crack initiation, a distribution law involving H_2 concentration, applied stress, and temp. is assumed, and the observed changes in lower critical stress discussed and explained on the basis of this law (21 refs).

Deformation, heating and melting of solids in high-speed friction F. P. Bowden and P. A. Persson (*Proc. Roy. Soc.*, 1961, **260A**, March 21, 433–458).

Recent advances in magnetic analysis K. Hoselitz (*Brit. J. Appl. Phys.*, 1961, **12**, April, 141–146) The method of estimating internal stresses by means of magnetic measurements has been refined so that a quantitative estimate of the internal stresses arising from plastic deformation of Ni or even Fe can be made. In special cases even inhomogeneous stresses can be magnetically estimated; the approach to saturation is related to the dislocation density and a fair amount of information can also be obtained about non-magnetic inclusions and precipitates in a magnetic material from a critical assessment of its coercivity. Torque measurement curves and study of rotational hysteresis enables a comprehensive analysis of the shape, size, and density of magnetic precipitates. Magnetic viscosity measurements are used in the study of structure (18 refs).—C.V.

The structure of non-destructive testing K. W. Andrews (*Brit. J. Appl. Phys.*, 1961, **12**, April, 127–133).

Possible and attained improvements in the quality of permanent magnet materials H. Fahlenbrach (*Metall.*, 1960, **14**, Oct., 984–987)

Thermal distortion in steel plates for a proton synchroton magnet R. J. Wakelin (*Research*, 1961, **14**, March, 100–106).

The state of the German Collective Investigation on high temperature steels by long-time creep tests at 400 to 750° K. Richard and H. Reiner (*Brit. Electric & Allied Ind. Res. Assoc.*, J/E/T 215, 2–10; International Discussion on Long-Time Performance of High Temperature Steels, Düsseldorf, June, 1960) The results obtained with some 50 steels are tabulated in considerable detail, 1000, 10000, 25000, and 50000 h findings being recorded. The extrapolated results for 100000 h are discussed and the query is raised as to whether these will agree with actual tests when these are forthcoming.—C.V.

Comments on Lozinsky and Simeonova's paper O. D. Sherby (*Acta Met.*, 1959, **7**, Nov., 709–715) on '*Superhigh plasticity of commercial iron under cyclic fluctautions of temperature*'. A letter.—S.H.-S.

Liquid-solid phase distribution studies in the systems iron–lead, cobalt–lead, chromium–tin and nickel–silver D. A. Stevenson and J. Wulff (*Trans. Met. Soc. AIME*, 1961, April, **221**, 271–275).

Influence of plastic deformation at low temperatures on the heat-resisting properties of austenitic steel type 18–8–Ti A. P. Gulyaev and I. V. Chernenko (*Issledovaniya po zharoprochnym splavam*, 1959, **4**, 214–217) Steel 1Kh18N9T was chosen because of the capacity of the austenite to undergo $\gamma\rightarrow\alpha_2$ transformation in the plastic deformation process. One interesting conclusion was that the double $\gamma\rightarrow\alpha_2\rightarrow\gamma_2$ transformation facilitates an increase in long-time strength, but only for temperatures not exceeding 600°, and for a limited test period. By encouraging an increase in strength, this transformation in all cases had a negative effect on creep rate. This was considerably accelerated.—A.I.P.

Scatter of creep strength of steel X22 CrMo (W) V1–A joint evaluation of German tests R. Schinn (**International Discussion on 'Long time behaviour of high temperature steels'*, Düsseldorf, 1960, No.5).

Effect of the alloy content on austenitic heat-resisting steels T. Fujita and T. Sasakura (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1399–1401) Creep-rupture tests are carried out and the results illustrated for three different specimens

Martensite the cause of the failure of a steel rope Z. Steininger (*Hutnik*, 1961, **28**, (3), 127–130).

Approximate conversion values for the hardness and tensile strength of steel (*Aciers Fins. Spéc.*, 1960, Dec., **36**, 86–90).

Analysis for the ball indentation hardness K. Kuroki (*Trans. Japan Soc. Mech. Engrs.*, 1960, **26**, Oct., 1435–1443; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 480) Relations were found between load, ball dia., yield stress, and depth of indentation. Conversion formulae and corrections for various hardness scales were obtained.

Studies on high speed classification arrangement in hardness testing. (1) R. Tsukada and K. Naito (*Rep. Tokyo Metropol. Ind. Res. Inst.*, 1960, (11), Sept., 22–24; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 480) [No abstract].—C.F.C.

Impression of Vickers hardness. (3) N. Ohta and S. Sano (*Rep. Tokyo Metropol. Ind. Res. Inst.*, 1960, Sept., 1–4; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 480) [No abstract].—C.F.C.

A study of some peculiarities in the shape of hardness curves of end quenched and tempered steels H. R. S. Rao and V. G. Paranjpe (*Trans. Indian Inst. Met.*, 1960, **13**, Sept., 205–237; discussion 238–240).

Measurement of hardness at very high temperatures L. M. Fitzgerald (*Brit. J. Appl. Phys.*, 1960, **11**, Dec., 551–554).

Application of statistics to metal industries; especially application of multiple correlation to the steel industry. (2nd Report). The investigation of hardness gradients in the Jominy curve of low chromium steel T. Araki and T. Morimoto (*Suiyokwai-Shi*, 1960, **14**, Dec., 208–211).

Hardenability of constructional steel L. N. Davydova (*Stal'*, 1961, (6), 551–557) Comparison of samples of the same grade as produced by different works showed that properties correlated closely with composition and grain size and were little affected by conditions of manufacture.

Effect of stress-ageing on the static and fatigue strength of carbon steel T. Sakurai, T. Kawasaki, and H. Izumi (*Proc. 2nd Japan Congress on Testing Materials*, 1959, 30–33) The experiments described indicate that the static strength, especially the elastic strength can be markedly improved by stress-ageing; the dynamic yield point can also be increased, but not the fatigue limit. The results are explained in terms of dislocation theory (12 refs).

Effect of plastic strains on mechanical properties of five steels C. F. Tipper (*Brit. Weld. J.*, 1961, **8**, May, 278–281) The effects of plastic strain, ageing, and stress relieving have been studied by notch impact and tensile tests on five 1in mild steel plates. Strains not exceeding the yield point (4–5%) shifted the Charpy V-notch curves to higher temp. and the 15 ft-lb transition by from 20 to 30°C. Stress relieving at 650°C brought the curves back towards the original values but only in one steel was recovery nearly complete. Samples cut transverse to the direction of rolling and straining showed less recovery.

Strain-ageing in rimming steel using the Swift cupping press D. K. O. Ullmann and V. M. Thomas (*Sheet Metal Ind.*, 1960, **37**, Sept., 640–646, 690) The experiments reported in this paper were carried out to determine whether the Swift cupping tests can follow the progress of strain-ageing in cold reduced, skin-passed rimming steel. Flat-nosed, hemispherical and ellipsoidal punches were used. The authors conclude that the Swift cupping test does not discriminate sufficiently between changes in properties at various stages in ageing.—A.H.M.

Theoretical research on the initiation and propagation of brittle crack with special reference to SOD test Y. Akita and K. Ikeda (*J. Soc. Naval Arch. Japan*, 1960, July, 287–292; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 474) In the theory of brittle crack propagation, the dynamical effects are added to the Griffith's energy condition. At room temp., the plastic work done occurring in 'shear lip' zone was also considered besides the 'surface work' proposed by Orowan. The conditions of the initiation of crack were obtained considering both the energy and the yield stress. The mechanism of initiation in the SOD tests, Esso Brittle Temperature, and the temperature-depending critical stress were disclosed theoretically.—C.F.C.

A proposal concerning a propagation test of brittle cracks. The notch tensile test of 'cross welded steel plate' H. Oba (*J. Soc. Naval Arch. Japan*, 1960, Dec., 305–316; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 554) [No abstract].—C.F.C.

Effect of notch shape on the brittle fracture strength of welded steel plate H. Kihara and H. Oba (*J. Soc. Naval Arch. Japan*, 1960, Dec., 317–326; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 553) Effects of notch characteristics are confirmed following criticism of a previous paper.

A study on the propagation of brittle fracture. (1) On the dynamical stress distribution and the released elastic strain energy M. Yoshiki, T. Kanazawa, and H. Itagaki (*J. Soc. Naval Arch. Japan*, 1960, Dec., 347–354; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 474) Calculations for a crack extending at constant velocity under uniform stress are made and conclusions on energy release and stress distribution are drawn.

On the critical temperature for propagation of a brittle crack in a steel plate F. Koshiga (*J. Soc. Naval Arch. Japan*, 1960, Dec., 355–363; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 479) The double tension test gives values for critical temp. closely correlated with the 50% crystallinity transition temp. of the pressed-notch Charpy test. Conditions simulating service were employed.

Effect of residual stresses on the behaviour of brittle fracture-propagation H. Kihara and T. Kusuda (*J. Soc. Naval Arch. Japan*, 1960, Dec., 385–393; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 553) Changes of direction in cracks near welds were observed and studies on plates with symmetrical welds were made. It is concluded that the crack propagates in the direction perpendicular to max. tensile stress arising from residual and applied stresses and becomes unstable in the compression region.

Brittle crack propagation test by large tension specimens with pressed and aged notches H. Kihara and N. Ogura (*J. Soc. Naval Arch. Japan*, 1960, Dec., 395–402; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 554) Pressed and aged notches are proposed for studies on crack propagation as initiation becomes easy. At $\frac{2}{3}$ of the yield stress cracks form without impact.

Studies of brittle fracture propagation in six-foot-wide steel plates with a residual strain field F. W. Barton and W. J. Hall (*Ship Structure Comm.*, 1961, *SSC* 130, April, pp.49) A report of an investigation of the effect of residual stress on crack propagation speed and strain response, during brittle fracture of 6 ft wide steel plates. The residual stress, which was provided by welding tapered slots, was found to aid initiation of the cracks, but to slow down their propagation.—A.W.D.H.

On the brittle fracture of a mild steel under repeated impacts K. Endo and K. I. Nagai (*Proc. 2nd Japan Congress on Testing Materials* 1959, 44–46).

Prevention of brittle fracture in welded structures H. Kihara and K. Masubuchi (*Proc. 2nd Japan Conference on Testing Materials*, 1959, 94–97).

Crack propagation tests of high-strength sheet materials. Part V. Air-melted and consutrode AMS 6434 steel C. B. Beachem and J. E. Srawley (*PB* 161697, 1960, Aug., pp.22; *NRL rept.* 5507; from *US Res. Rep.*, 1960, **34**, Dec. 16, 759) AISI 4335 with V was used. Austenitizing and tempering temp. are established. Vacuum-remelted was better than air-melted metal.

On the hydrogen brittleness of mild steel (based mainly on the results of mechanical tests) I. Ohnishi and Y. Kikuta (*Proc. 2nd Japan Congress on Testing Materials*, 1959, 113–115).

Heat resistance of ferrite alloyed with chromium, vanadium, tungsten, and molybdenum O. A. Bannykh and I. F. Zudin (*Issledovaniya po zharoprochnym splavam*, 1959, **4**, 273–279) The effect of Mo on heat-resistance was much greater than that of other additions investigated. Alloys with two alloy components one of which was Mo, had a heat-resistance only slightly less than that of the alloy alloyed with Mo alone. Other results are given.—A.I.P.

The effect of carbon on the magnetic properties of transformer steel G. N. Shubin, V. V. Druzhinin, V. A. Koroleva, T. I. Prasova, M. I. Sherstyuk, and L. K. Kurennykh (*Stal'*, 1961, (5), 445–448) Reduced C content by vacuum annealing of coarse-grained transformer steel decreases hysteresis but increases eddy current losses, in fine-grained steel the eddy current loss increase is less marked. Transformation of cementite to graphite reduces specific losses. Cementite inclusions and particularly finely divided carbon have very adverse effects.

Investigation of the order–disorder transformation in FeAl alloys L. Pál and T. Tarnóczi (*Proc. Central Research Institute for Physics of the Hungarian Academy of Sciences*, 1959, **7**, 5, 265–275; from *Hungarian Techn. Abs.*, 1960, **12**, (4), 131).

Paramagnetic susceptibilities of Fe and Fe–Si alloys S. Arajs and D. S. Miller (*J. Appl. Phys.*, 1960, **31**, June, 986–991).

Single-crystal magnetic anisotropy and magnetostriction studies in iron-base alloys R. C. Hall (*J. Appl. Phys.*, 1960, **31**, June, 1037–1038).

On the nature of the change of the coercive force upon the annealing of hardened low-carbon steel I. A. Bildzyukevich, Y. M. Golovchiner, and G. V. Kurdyumov ('*Problems of Metallography and the Physics of Metals*', ed. B. Ya. Lynbov. English translation: NY, 1959, 138–140) It is shown that the main factors resulting in the increase on coercive force are the martensitic transformation mechanism which results in the characteristic non-homogeneous micro and submicro structures

and stresses, the properties of the martensite crystals (martensite being a supersaturated solid solution of C in α-iron) and a certain heterogeneity of the hardened steel. The experimentation connected with this work is described. It is considered that considerable decrease in the coercive force resulting from relieving the internal stresses without changing the structure and without changing the position of the Fe-atoms, suggests that the high coercive force of hardened steel depends to a considerable extent on stresses of the second kind which result from the martensite transformation and from the high elastic limit of the martensite crystals.—C.V.

On the change of coercive force in low-temperature tempering N. S. Fastov (*'Problems of Metallography and the Physics of Metals'*, ed. B. Ya. Lynbov. English translation: 1959, 148–150) Stresses affect diffusion in solid solutions; during a diffusion process equalization of the chemical potential of the dissolved matter occurs and at a given temperature this is a function of concentration and stress. These redistributions of the stresses in a body cause a change in the stress-dependent properties and one of these is coercive force. These changes are examined mathematically, the special case presented being that in which the lattice deformation in the microstress region does not change during the diffusion process. Any deformation can readily be checked from the change in width of the X-ray interference lines.—C.V.

On the coercive force and the width of the X-ray interference line in low-carbon alloyed steels Y. M. Golovchiner and V. M. Golubkov (*'Problems of Metallography and the Physics of Metals'*, ed. B. Ya. Lyubov, English translation, NY, 1959, 151–154) Using hardened and tempered low-C steels, alloyed with strong carbide forming elements, Mo or V, hardness remains unchanged with heating to 500° but with further rise the hardness first increases and then diminishes sharply forming a peak of 'secondary' hardness. Below 500° the carbide phase does not separate out but at the higher temp., 550–600°, a special carbide is formed. The steels used were (a) 0·11%C, 1·48%Mn, 1·40%V, and (b) 0·10%C, 1·16%Nb. From the given data it is concluded that within the temp. range, the steel remains homogeneous and there is no decrease in lattice distortion. The views of various workers are discussed.

Anomalous magnetostriction of the 'grain-oriented' silicon–iron sheet Y. Shirakawa and K. Numakura (*Nature*, 1961, **190**, May 6, 523) A letter. An explanation of the departure of the observed from the theoretical curve is offered.

Demagnetization of ferromagnetic particles F. Smith (*Brit. J. Appl. Phys.*, 1961, **12**, April, 155–159).

On the mechanism of reversible appearance of residual magnetization at low temperature transition in α–Fe_2O_3 K. Siratori, A. Tasaki, and S. Iida (*J. Phys. Soc. Japan*, 1960, **15**, Dec., 2357–2358).

Antiferromagnetism of $FeSn_2$ K. Kanematsu, K. Yasukochi, and T. Ohoyama (*J. Phys. Soc. Japan*, 1960, **15**, Dec., 2358).

Non-destructive inspection of electric resistance-welded pipe T. Manis (*ISA Proc.*, 1960, **10**, (8), 1–11).

Inspecting jet engine parts with eddy currents R. L. Lipe (*Met. Prog.*, 1961, **79**, March, 129–131).

An investigation of electrolytic conductivity in iron–aluminium alloys in the solid state S. D. Gertskiken, I. Ya. Dekhtyar, V. S. Mikhalenkov, and E. G. Madatova (*Issledovaniya po zharoprochnym splavam*, Moscow, 1960, **6**, 99–104) A new method, based on the displacement of inert indicators, was used for investigating electrolytic conductivity in solid solutions. In a number of cases this effect has been found to exist in many single-phase systems with metals capable of mutual diffusion (8 refs).—A.I.P.

Nondestructive inspection of steel tubular products E. B. Henry (*ISA Proc.*, 1960, **10**, (7), 1–6) Ultrasonic testing is described.—C.V.

Ultrasonic control of the welded joints of welded/cast structures I. N. Ermolov (*Lit. Proizv.*, 1958, (11), 29–32) The great thickness of the welded joints (500 mm and over) prevented the application of gamma and X-ray defectoscopy. Earlier attempts to use ultrasonic defectoscopy for welded/cast parts met with difficulties because of the ultrasonic distribution in cast metal. Therefore a new ultrasonic defectoscope (UDTs–11) has been built and special control methods have been evolved. Details are given.—A.I.P.

Immersion ultrasonic inspection used to check steel plant products Timken Roller Bearing Co. (*Iron Steel Eng.*, 1961, **38**, Feb., 141–142).

Use of ultrasonics in testing for cleanliness A. C. Mager (*AIMME, Proc. OH Conf.*, 1960, **43**, 72–84) The author reports process in an investigation at Heppenstall Co. in which the ultrasonic reflectoscope is used to determine the factors affecting steel cleanliness. The method allows changes in procedure to be evaluated, and an entire heat may be tested non-destructively and on a production basis.—G.F.

Use of X-Ray fluorescence in metallurgy G. Pomey (*Mech. Elec.*, 1961, **45**, March, 36–40) [In French] This paper attempts to explore the possibilities of X-ray fluorescence analysis in metallurgy particularly ferrous metallurgy. Research carried out by IRSID and other research laboratories is described. Aspects dealt with include instrumental factors, analysis of iron ores, and slag from iron and steelworks.

Stereoscopic microradiography W. M. Williams (*Metallurgia*, 1961, **63**, Feb., 95–101) The principles of stereoscopic microradiography are presented and discussed and the advantages of the method are outlined. Examples of its application to the radiographic examination of metallurgical microstructures are illustrated by stereo pairs. The method may also be used for quantitative examination of microstructural features. By way of illustration the morphology of a single grain from a polycrystalline Al alloy is examined.—S.H.-S.

Effects of inhibitors on H_2 embrittlement C. Meyer (*Iron Steel*, 1960, **33**, Nov., 536–539) The proportion of the H_2 evolved during pickling which is absorbed by the steel was investigated, using 17 proprietary inhibitors. All inhibitors gave some protection, but only one gave substantial protection.

Abrasive wear measurement of high-manganese steel abraded by various ore sands Y. Kido and H. Fujii (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1386–1388) Aspects dealt with include the relation between abrasive wear and hardness, the hardness distribution of high-Mn and austenitic Cr–Ni–Mo steel specimens after testing.

Study of non-metallic inclusions. VII. Products of deoxidation due to special elements H. Kimura and M. Kawai (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1360–1361) Melting analysis of samples is given and micrographs illustrate the deoxidation products due to addition of Cr,V, Ti, and B.

On the microscopical structure and chemical composition of inclusions in steel T. Onuki, Y. Koike, and T. Chiba (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1361–1364) Tables also give details of the micro-Vickers hardness of samples.

On the behaviour of non-metallic inclusions in the blooming of rimmed steel ingots by the Klinger Koch method Y. Shimokawa, T. Fujii, and T. Yamamoto (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1364–1366) Tables illustrate the rolling method used and show the chemical composition of inclusions extracted from the centre of ingots and blooms. The relation between elongation of spherical inclusions and elongation of ingots in blooming is illustrated graphically.

Effect of non-metallic inclusions on induction hardening crack susceptibility H. Homma (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1366–1369) Tables give details of the induction hardening conditions applied, the chemical composition, cleanliness, and γ-grain size for the heats and a crackability index of all specimens.

On the sulphides of leaded high sulphur free cutting steels: Part I C. Asada, R. Kadowaki, and K. Kato (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1386–1388) Extracted sulphides are analyzed chemically and by X-rays and illustrated after magnetic separation. Their micro-Vickers hardness is shown as well as their behaviour on drawing.

Effect of cold working on carbide precipitation of austenite high-manganese steel Y. Imai and T. Saito (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1388–1390).

Macroscopic non-metallic inclusions in tubes of high-carbon chromium ball-bearing steel E. Miyoshi (*Tetsu-to-Hagane*, 1960, **46**, Dec., 1744–1751) The accuracy of visual inspection on lathe cuts is estimated. Only about 10% of the total inclusions visible in the microscope were found.

The stability of europium oxide in silicon-bearing stainless steel C. F. Leitten jun. (*ORNL*–2946, pp.83; from *US Res. Rep.*, 1960, **34**, Dec. 16, 808) [No abstract].—C.F.C.

Behaviour of non-metallic inclusions at tensile test J. Watanabe (*Proc. 2nd Japan Congress an Testing Materials*, 1959, 98–99) The polished surfaces of tensile specimens were observed under the microscope at up to ×2 000 before and after loading, and the behaviour of non-metallic inclusions at the surfaces was studied. Slightly in excess of the yield point concentrations of strain at the corners of the inclusions leading to microcracks were observed on transverse specimens, and breakdowns of the inclusions and stress concentrations at the new edges so formed were found.

Concerning the question of the distribution of components between the solid and liquid phase in alloys Ya. N. Malinochka (*Izvest. AN Otdel. Tekhn. Met i Toplivo*, 1961, (2), 141–143) Arguments presented and experimental data indicate that B. A. Movchan was in error and that there is no basis for talking of a special equilibrium composition of liquid at the interface boundary and in the narrow gaps between crystals.—A.I.P.

Modifications of non-metallic inclusions in the course of melting and casting of steel killed with manganese and silicon V. A. Mchedlishvili and A. M. Samarin (*Translation of Physico-chemical principles of steelmaking*, 602–631) [In French].

Ferrite grain boundaries in iron and low-carbon steels I. Hrivňák (*Met. Treatment*, 1961, **187**, April, 133–143) The author presents evidence of the presence of multi-step grain boundaries in iron and low-carbon steels. It is demonstrated that the degree and manner in which the steps are revealed are dependent on the etching time only. The author considers the origin of the phenomenon to be in the crystallographic state of grain boundaries.

Kinetics of the relaxation of low-carbon steel and its effect on the recrystallization process G. K. L'vov (*Izvest. AN Otdel. Tekhn. Met. i Toplivo*, 1961, (2), 95–98) Relaxation is a process of the diffusion-less relieving of elastic distortions of the crystal lattice. The process takes place at great speeds, which however, are measurable. Relaxation has no marked effect on the course of the final stage of the process of recrystallization working.

Effect of hot working and heat treatment on austenite grain size T. Arakawa and S. Oda (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1354–1356).

On the wear phenomenon of titanium cast iron with eutectic graphite structure E. Takeuchi (*Imono*, 1960, **32**, Sept., 635–641).

Contact stress and load as parameters in metallic wear A. Dorinson and V. E. Broman (*Wear*, 1961, **4**, March–April, 93–110) The rate of metallic wear was investigated under two conditions of constant stress, the load being varied as the area of contact changed. Wear was found to occur at an initially rapid rate, which levelled off, but was followed by a further increase, and the rate, at equivalent stages, depended on the nominal applied stress. A theoretical model was presented to explain this behaviour.—A.W.D.H.

Relation between wear rate and debris composition in wear of wrought iron and mild steel B. J. Nield and O. G. Griffen (*Wear*, 1961, **4**, March–April, 111–122) Wear rates of cylindrical samples of wrought iron and two mild steels were measured under conditions of constant load. It was found that two types of wear loss-time curve could occur, depending on the relative humidity of the ambient atmosphere. The chemical nature of the debris was ascertained, using X-ray diffusion analysis, and was found to change as wear progressed.—A.W.D.H.

Study on wear in the shearing process by

means of irradiated tools T. Sata, K. Abe, and K. Nakajima (*Sci. Pap. Inst. Phys. Chem. Res.*, 1960, **54,** Sept., 307–312) [In English] The wear of irradiated punches and dies can be followed by measuring the activity of punched pieces and sheets. The testing time is shortened, compared with conventional processes, since the stationary state of tool wear is reached after punching only some hundreds of sheets. The effects of tool clearance, sheet material, and lubricants are examined.

An electron-microscopical study of friction and wear R. Weil and R. A. Paquin (*Wear*, 1961, **4,** March–April, 123–136) The coefficients of friction were measured between a steel sphere and several nickel, copper, and chromium surfaces electrodeposited under different conditions. The tracks were examined with the electron microscope, and the damage was found to vary as the calculated ratio of the welded to the contact area. A relationship between wear, surface roughness, and work hardening was formulated.—A.W.D.H.

Wear and friction under rolling with slip B. N. Das, R. Choubey, and K. C. Goswami (*NML Techn. J.*, 1960, **2,** Nov., 15–21).

Effect of the surface state of test-pieces on the friction coefficient and other parameters during the rolling of iron under a vacuum Ya. B. Gurevich, A. M. Zubko, I. M. Pavlov, and Yu. M. Sigalov (*Izvest. AN Otdel. Tekhn. Met. i Toplivo*, 1961, (2), 144–145) With a decrease in the degree of roughness of test-pieces in extreme limits a decrease in the friction coefficient is observed by a factor of 1·3 (from 0·46 to 0·35).—A.I.P.

A study of factors which affect the wear-resistance of castings made from steel G13L N. P. Zhetvin (*Stal'*, 1961, (6), 557) A note from 'Serp i Molot'. A tracer study on the time taken for C distribution to become uniform has been made. Properties, including wear-resistance, were measured.

Testing of wear resistance of brake shoes F. Varga and E. Füle (*Koh. Lapok-Öntöde*, 1961, **12,** March, 60–62).

Measurement of the wear rate of cast grinding balls using radioactive tracers J. D. Keys and G. G. Eichholz (*Can. Mines, Tech. Bull.*, 1960, TB 18, pp.14).

Causes of corrugations in the running surface of railway tracks A. Dressler (*Eisenbahntechnische Rundschau*, 1960, **9,** Dec., 558–559; from *Monthly Rev. Tech. Lit.*, 1961, **11,** April, 3).

A reflected light method for the detection and photography of defects on polished surfaces P. J. E. Forsyth and D. A. Ryder (*RAE Tech. Note No. Met.* 298, 1958, Oct., 1–5) A method has been devised for the detection of defects such as 'Brinelling' on polished surfaces, particularly ball races and ball bearings. These defects due to their shallow and smooth nature are not clearly revealed by conventional microscopy.—C.F.C.

Magnetic measurements in metallurgy J. E. Goldman and A. Arrott (*ASM STP*, 1959, 93–111) The applications of magnetic measurements in the science of metals are tabulated and one example from each of the classifications enumerated is developed and other areas are simply summarized.—S.H.-S.

Metallurgical structure and magnetic properties J. J. Becker (*ASM STP*, 1959, 68–92) The specific importance of domain structure in determining magnetic properties is emphasized and a new technique for the observation of domain boundaries is described. Two completely new phenomena, superparamagnetism and exchange anisotropy, are also described, with special reference to their occurrence in alloys.—S.H.-S.

Spin clusters in iron near the Curie temperature B. L. Averbach (*ASM STP*, 1959, 280–287).

Non-uniformity of magnetic properties in a stack of sheets of transformer steel L. P. Ershova and A. I. Korsunskaya (*Stal'*, 1961, (6), 546–548) Non-uniformity of temp. conditions gives rise to variations in the sheets from top to bottom, and to a smaller extent, over the length and width of the sheets in the stack. Sorting of the sheets according to their magnetic properties is advised.

Non-destructive tests for detecting faults in metal parts (**T.I.S. No.22**) G. G. M. Carr-Harris (*National Research Council of Canada*, 1951, pp.14; from *DSIR TIDU* 6175).

Non-destructive testing of small tubing J. R. Grieve and A. M. Bounds (*Met. Prog.*, 1960, **78,** Dec., 110–114, 126, 128).

Progress in non-destructive testing of steam turbine generator components C. D. Moriarty (*Nondestr. Test.*, 1961, **19,** Jan.–Feb., 29–38).

Ultrasonic inspection of submarine steel weldments N. A. Sinclair and M. M. Nanda (*Nondestr. Test.*, 1961, **19,** Jan.–Feb., 58–64) The paper details a laboratory investigation aimed at developing ultrasonic inspection techniques for butt weldments in ship plate which would be equivalent to radiographic standards. Both ultrasonic and radiographic tests were carried out under identical conditions in which both weld metal and heat affected zone were explored for cracks, inclusions, and porosity. It is concluded that ultrasonic standards could be established for cracks but not for inclusions and porosity.—A.H.M.

Five years of ultrasonic rail testing on the Southern Region J. Banks (*Permanent Way; Institution, Journal*, 1950, **78,** (2), 106–115. from *Monthly Rev. of Tech. Lit.*, 1961, **11,** April, 3).

Ultrasonic determination of elastic constants, at room and low temperatures N. H. Fahey (*WAL TR* 118.1/1; *PB* 16154, 1960, April, pp.14) Bulk, shear and elastic moduli, and Poisson's ratio were determined on a variety of materials on a machine operating within the range of frequencies 1–9 megacycles. Steel and non-ferrous alloys were tested, and the effects of specimen geometry, machining finishes and other factors were examined.

Checking and recording results of ultrasonic flaw detection S. Ludvik (*Zváranie*, 1961, **10,** (5), 139–142) [In Czech].

The continuous recording method of thickness testing using an ultrasonic thickness tester Y. Maebashi (*Proc. 2nd Japan Congress on Testing Materials*, 1959, 227–230) Experiments are described on plate, steel pipe, and a corroded gas cylinder, using a DG instrument.

Design for the application of ultrasonic energy to metallurgical processes D. E. Gücer (*Bull. Techn. Univ. Istanbul.*, 1960, **13,** (2), 69–82) [In English] A description of an apparatus which has been constructed to investigate the effect of ultrasonic energy upon the WC–Co liquid sintering process. The apparatus enables close control of the acoustic variables to be achieved, and a method of calculating the energy transmitted to the specimen is proposed.—A.W.D.H.

Autosonics—problems and experiences in automatic production testing C. A. Rankin (*Materialprüfung*, 1960, **2,** Nov., 421–428).

X-Ray measurement of intragranular misorientation in metals (*NBS Tech. Bull.*, 1961, **45,** Feb., 19–20) A short description of an instrument based on a double-crystal spectrometer which can be used to measure intragranular misorientation produced in metals by plastic deformation is given.—A.W.D.H.

An X-ray analysis of the strain in steel due to impulsive loads G. Moss, S. Golaski, and C. Glass (*PB* 149884, 1960, June, pp.12; *Technical Note No.* 1320, from *US Res. Rep.*, 1960, **34,** Dec. 16, 759) A rod of pearlitic 1030 steel was subjected to an impulsive load, recovered, and analyzed for X-ray diffraction line broadening at a cross-section which had been exposed to a maximum pressure of approximately 35 kilobars. The broadening of the diffraction peaks was then plotted versus sec. θ and θ in order to establish whether or not the primary mode of deformation was due to lattice fragmentation or micro-strain. The results indicated that deformation was not simple enough to be interpreted according to either of these models, for the broadening was probably due to both micro-strain and lattice fragmentation.—C.F.C.

Time dependence of resonantly filtered gamma rays from Fe^{57} F. J. Lynch, R. E. Holland, and M. Hamermesh (*Phys. Rev.*, 1960, **120,** Oct. 15, 513–520).

Precipitation and irradiation hardening in iron D. Hull and I. L. Mogford (*Phil. Mag.*, 1961, **6,** April, 535–546) Precipitation of carbon during irradiation and thermal ageing has been studied using thin film electron transmission microscopy. The precipitates were in the form of plates parallel to {100} and occurred individually in the matrix, or in rows along the dislocation lines. However, thermal ageing alone at the same temperature produced clusters of plates in the matrix, as well as the rows along the dislocation lines. At higher temp. the precipitates were of dendritic or acicular shape. The defects formed during radiation hardening were not detected, and this hardening was found to be most pronounced when precipitation did not occur.

Irradiation of some pressure-vessel steels L. P. Trudeau (*ASTM STP*, 1960, (276), 102–115) Nine steels were examined: ASTM A 201 (*I*) A 203, A 302, A 353 (*II*), US Navy HY–65 (*III*), HY 80 (*IV*), commercial T01 (*V*), A. O. Smith 1146 Ni–Mn–V plate, and Smithweld 91; the analysis and tensile strengths of these are tabulated. Except in the case of *II*, and possibly *IV*, all had transition temp < room temp., the superiority of *IV* being noteworthy. *III* was the poorest and it is noted that both *III* and *V* contained Cu. In every case, including *IV* and *V* and the quenched and tempered steels, the transition curve has a low energy shelf and if these low-energy shelves correspond to regions of crack arrest the quenched and tempered structure would possess still greater advantages. The presence of $\sim$10% austenite in a II-steel should contribute to a retention of toughness since this does not seriously embrittle with irradiation and should act as a crack barrester. I and a ferrite (*VI*) are compared and *VI* had both a lower transition temp. and less shift with irradiation.

Dynamic radiation effects testing methods D. M. Newell, E. E. Kerlin, R. R. Bauerlein, and R. F. Barrows (*ASTM STP*, 1960, (276), 137–146).

X-Ray analysis of the carbide phase of patented steel wire V. M. Golubkov and V. K. Kritskaya ('*Problems of Metallography and the Physics of Metals*', ed. B. Ya. Lyubov, English translation, NY, 1959, 322–325) The material investigated was the carbide precipitate removed from patented steel wire (0·8%C) after deforming it by 25, 75, and 95% and tempering at 400, 600, and 680°C. The carbides were removed electrolytically and washed and dried in CO_2. X-Ray examination showed blurring the degree being caused by the various treatments and comparison with the control show that this phenomenon is entirely due to the fragmentation of the coherent regions of the carbide crystals and the blurring of the (112, 021) interference lines enable the size of the blocks in the cementite crystals to be estimated after each treatment. Upon cold plastic deformation (drawing, with total reduction 75%), the blocks (regions of coherent scattering) are considerably more fragmented and the dimensions of the coherent sections of the cementite approach 10^{-6}. This data, with that of the α-phase, show that the structural components of this system are exceedingly dispersed after this treatment; this was not found with any other form of heat-treatment. The implications of these findings are discussed.—C.V.

Studies of 'temper-rolling', using X-ray diffraction M. Humbert, S. Jeunehomme, H. Lambot, and F. Montbrun (*Extrait du Compte-Rendu du XXXe Congrès International de Chimie Industriel*, 1958, Sept., 103) An X-ray diffraction method for controlling and studying the effect of temper rolling is described. Special consideration is given to ageing, grain size, annealing temp., thickness of sheet, and surface finish.—R.P.

Investigation of the variation of intensity of X-ray interference lines of deformed steel V. A. Ilyina and V. K. Kritskaya ('*Problems of Metallography and the Physics of Metals*', ed. B. Ya. Lyubov, English translation, NY, 1959, 295–298) The influence of plastic deformation on the state of the crystal lattice is studied. Deformation has been carried out by rolling, drawing, filing, pulverizing, or high work-hardening. Measurements of the intensity of the deformed and undeformed Fe in an Mo-radiation at two temp. (+23 and −185°) show that the change in intensity (thermal intensity coefficient) resulting from a 200° reduction in

temp. of the specimen varies equally for both the deformed and undeformed Fe. The results obtained differ from those of Averbach; this is discussed.—C.V.

Structure of the energy spectrum of chromium and iron electrons in iron–chromium alloys N. D. Borisov, V. V. Nemoshkalenko, and A. M. Fefer (*Issledovaniya po zharoprochnym splavam*, 1959, **4**, 78–89) A scheme has been constructed covering the energy levels of chromium and iron with a change in indicated energy levels of chromium and iron on transfer of the given metals into Fe–Cr alloys with a different concentration of components and phase (γ–α–σ) transformations.—A.I.P.

Effect of nickel concentration on the structure of the energy spectrum of chromium and iron electrons N. D. Borisov, V. V. Nemoshkalenko, and A. M. Fefer (*Issledovaniya po zharoprochnym splavam*, Moscow, 1960, **6**, 130–135) Characteristic changes were established which take place in the structure of the energy spectrum of electrons of Fe–Cr alloys as a result of their alloying by a third component Ni. The method is described, data obtained are listed in four tables, and results are analysed (8 refs).—A.I.P.

The betatron and its uses in metallurgy A. V. Francis (*Met. Constr. Mecan.*, 1961, **93**, May, 435–449) [In French].

Radioactive ring wear testing in railroad diesel locomotives C. F. Jursch, P. L. Pinotti, and D. R. Jones (*ASTM, STP*, 1959, (268), Oct. 13, 3–14) Tests demonstrated that (1) the tracer technique has proved to be an excellent tool for investigating a wide variety of factors that influence ring wear in railroad diesel locomotives; (2) the method can be utilized with equal success in both two and four-stroke cycle railroad diesel engines; (3) with proper monitoring and safety suspension radioactive piston ring tests can be run in diesel locomotives without undue hazard to operating and maintenance personnel.

Radiation damage in steel: considerations involving the effect of neutron spectra A. D. Rossin (*ASTM, STP*, 1960, (286), June 29, 145–156).

Reactions of iron-54 with alpha-particles S. Tanaka, M. Furukawa, S. Iwata, M. Yagi, H. Amano, and Takashi (*J. Phys. Soc. Japan*, 1960, **15**, Sept., 1547–1551).

Fundamentals for the development of a plant viscometer E. E. Hofmann and N. K. Das (*Arch. Eisenh.*, 1961, **32**, April, 199–208) A rotating body for a torsion viscometer for slags has been developed, which is not affected by the depth of immersion or by the distance from the receptacle wall and bottom. This rotating body is characterized by a thin shaft and has performed satisfactorily under plant conditions.—M.L.

Investigation of heat-resistance and structure of certain iron-based alloys in relation to composition S. D. Gertsriken, I. Ya. Dekhtyar, and L. M. Kumok (*Issledovaniya po zharoprochnym splavam*, Moscow, 1960, **6**, 259–267) The aim was to find new heat-resisting iron-based alloys suitable for long-time operation at elevated temp. as gas-turbine parts. Alloys were prepared in an argon atmosphere in a high-frequency vacuum furnace from pure metals. Results are given of heat-resistance, weldability, and X-ray examinations.—A.I.P.

The effect of cold hardening on the endurance of heat-resisting steels at high temperatures I. V. Kudryavtsev and B. I. Aleksandrov (*Obrabotka zharoprochnym splavov*, Moscow, 1960, 41–52) As a result of experimental work the effect has been established of through and surface deformations on the endurance and sensitivity to stress concentration at elevated working temperaturse of 12 heat-resisting steels (10 refs).—A.I.P.

A periodic measurement of the coefficient of heat absorption of metals A. S. El-Darwish (*Thesis No.2800, Eidgenössische Technische Hochschule in Zürich*, 1958, Jan., 1–43).

Determination of vapour tension of solid cobalt in iron using radioactive isotopes Y. V. Kornev and V. N. Golubkin (‘*Problems of Metallography and the Physics of Metals*’, ed. B. Ya. Lyubov, English translation, NY, 1959, 299–311).

Further data on the elevated temperature behaviour of 18/8/Nb type austenitic steel H. W. Kirby and R. J. Trumen (*Brit. Electric & Allied Ind. Res. Assoc.*, J/E/T 217, 15–21; International Discussion on Long-Time Performance of High Temperature Steels, Düsseldorf, June 1960, Paper 25) Equilibrium, in terms of loss of impact values and sigma phase formation, appears to be reached in 4–5 years at 650°. Examination of the rupture test-pieces from the same cast contradicted this earlier evidence since appreciably more sigma phase was found in test pieces undergoing creep strain than in those exposed without applied stress. It would appear that longer times than those originally anticipated from the stress-free series, are necessary to attain equilibrium at this temp.—C.V.

Steels for low-temperature application K. Posch and E. Krainer (*Berg. Hütten. Monatsh.*, 1960, **105**, Nov., 268–280) The dislocation theory is reviewed in relation to the low temp. deformation mechanism. Mechanical properties and transformation temp. of various steels at low temp. are discussed. Recommendations are made regarding the welding of steels to be used, at low temp. (25 refs).—R.P.

Mechanical properties of high strength 301 stainless steel sheet at 70°, −320° and −423°F in the base metal and welded joint configuration J. F. Watson and J. L. Christian (*ASTM STP*, 1960, (287), June 30, 136–149) The UTS elongation and notched to unnotched tensile ratio of several tempers of high-strength 301 stainless steel sheet were determined at 70, −320, and −423 t. Tensile strengths and elongation of the base metal and welded joint specimens were generally observed to increase between room temp. and −320°F and then to decrease between −320° and −423°F. The notched to unnotched tensile ratio remained close to 1·0 at −320°F and then dropped to about 0·92 at −423°F. The main factor was the austenite-to-martensite reaction which is known to be favoured by both low-temp. and high-tensile stress.

Radiation effects in steel L. F. Porter (*ASTM STP*, 1960, (276), 147–196).

A study of irradiation effects in type ‘A’ nickel and type 347 stainless steel tensile specimens S. H. Paine, W. F. Murphy, and D. W. Hackett (*Argonne National Laboratory, ANL* 6102, 1960, July, pp.43; from *US Res. Rept.*, 1960, **34**, Dec. 16, 804) [No abstract].—C.F.C.

Neutron radiation embrittlement at 500 and 650°F of reactor pressure vessel steels J. V. Alger and L. M. Skupien (*ASTM STP*, 1960, (276), 116–136) ASTM A 302 (*I*) (grades A and B), HY–65 (*II*) and SA–336 (*III*) steels were used. Irradiation damage occurred in all cases when exposed to an integrated flux of 2 to 3×10^{18} nvt (>0·4 ev) at 500°F. This was also found with E 9016 (*IV*) and E 10016 (*V*) weld materials in *I–III*. Brittle fracture resistance was reduced although tensile properties were not seriously affected from the point of view of ductility. Impact transition behaviour of *II* can be increased by as much as 200° but irradiation at 650°F causes no increase in transition behaviour suggesting an annealing out threshold temp. exists between these two temp. Transition behaviour of *IV* and *V* weld metal deposit is slightly less sensitive to this dosage than *II*-grade B wrought material. *III* forging alloy is the least sensitive to embrittlement damage of all the wrought materials examined.—C.V.

Radiative transport within an ablating body L. P. Kadanoff (*Trans. ASME C*, 1961, **83**, May, 215–225).

On high temperature properties of high strength stainless steels T. Fujita, H. Abo, and T. Sasakura (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1396–1398) The ageing characteristics and creep-rupture curves of high strength stainless steels are illustrated by graphs.

Thermal expansion of technical solids at low temperatures R. J. Corruccini and J. J. Gniewek (*NBS Monograph*, 1961, **29**, May, pp.22) This is a compilation from the literature on the thermal expansion of metals, other inorganic materials and plastics, for the use of designers of cryogenic equipment.—A.W.D.H.

How springs perform above 900°F W. R. Johnson and R. D. Crooks (*SAE J.*, 1960, **68**, Sept., 68, 69).

Determining the sublimation heats of iron in alloys of iron with chrome in the solid state M. P. Mateeva and L. I. Ivanov (Trans. of *Issledovaniya po Zharoprochnym Splavam* (USSR), 1957, **2**, 52–56; from *US Techn. Trans.*, 1960, **4**, Oct. 26, 474) A method is described for determining the sublimation heat of metals in a solid state by the principle of isotope exchange through the vapour phase.

Mechanical properties of structural materials at low temperatures R. M. McClintock and H. P. Gibbons (*NBS Monographs*, 1960, (13), June, pp.180).

Properties of metals at low temperatures R. E. Lismer (*Mach. Design*, 1961, **33**, March, 182–187).

Influence of pressure on the self-diffusion parameters of iron in iron alloys with small aluminium additions S. D. Gertsriken and M. P. Pryanishnikov (*Ukrain. Fiz. Khim.*, 1958, **3**, (5), 651–658) [In Ukrainian] Using A in a special chamber at up to 150 kg/cm^2 and a temp. range of 1 100–1 250°C, the effect of pressure on self-diffusion of iron was investigated in iron alloys with 0·27 and 0·39%Al. Pressure was found to cause a sharp decrease in self-diffusion activation energy and an increase in self-diffusion rate.

Effect of nitrogen on 12% chromium heat-resisting steels T. Fujita and T. Sasakura (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1392–1394) Aspects dealt with include the effect of N_2 on tempering hardness at each temp. and on tempering characteristics at 650°C. Creep rupture curves at 12 kg/mm^2 are shown.

Effect of N and B on the properties of 18Cr–12Ni austenitic stainless steel R. Nakagawa and Y. Otoguro (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1409–1411) Aspects dealt with include ageing hardness, the relation between tensile strength and elongation and temp. and effect of N_2 and B on creep-rupture time at 700°C.

Effect of additions of B and B plus Mo on Mn–Si steel (**Study on high strength low alloy steels** Y. Nishima, T. Odawara, T. Ishida, and I. Shimazaki (*Ann. Rep. Eng. Res. Inst. Univ. Tokyo*, 1960, **19**, Sept. 96–101) Tensile and yield strengths and hardness are increased by B addition if quenched, but not if furnace cooled. 0·005%B is the optimum, and with 0·5%Mo, properties are improved even with furnace cooling. B does not offset hardenability but B+Mo increase it.

Effect of P on properties of 19–9 DL type heat-resisting steel (**Part 2**) [**Study on the effect of P on properties of heat-resisting steel. II**] M. Yamanaka, K. Kusaka, and A. Tonooka (*Tetsu-to-Hagane*, 1960, **46**, Dec., 1764–1771) Hardness increases (after quenching and ageing) and >0·2%P accelerates over-ageing above 850°C. Rupture strength improves but elongation and impact value decrease. Rare-earth metals improve ductility, as does B. A new type of steel contains 0·3%C, 19%Cr, 9%Ni, 1·5%W, 1·5%Mo, 0·5%Nb, 0·2%Ti, 0·1%P, and 0·3 %rare earth metals.

Effect of Al, Al+Ti and W+V+Nb on properties of 38%Ni heat resisting alloy S. Koshiba, T. Konou, and S. Kimura (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1421–1422).

Effect of carbon, vanadium and boron on spring wire of 16 Cr–2 Ni stainless steel T. Fujihara and Y. Motomiya (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1372–1374) Aspects dealt with include effect of carbon content on hardening temp. and hardness and the effect of B and V on hardening temp. and hardness. Graphs show the effect of carbon and V. contents on tensile strength, degree of torsion and reduction of area.

Effect of manganese on high temperature properties of N-155 alloy R. Yoda, H. Yoshida, and Y. Sato (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1419–1421) Aspects dealt with include the relation between hardness and heating time at various temp. of N 155 alloy and 10%Mn alloy, the effect of Mn on rupture life and elongation at various temp. and the effect of Mn on deformation resistance and degree of working in the foregability test.

Effect of Mo, W and V on the behaviour of carbides in 12%Cr steel T. Fujita and S. Masumoto (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1395–1396) Various specimens are analyzed by X-ray. The effects of tempering temperature

and time on the change of composition of carbides extracted, and the change in hardness on tempering are shown in graphs.

Effect of Mo and W on properties of 18Cr–12Ni stainless steel R. Nakagawa and Y. Otoguro (*Tetsu-to-Hagane*, 1960, **46**, Dec., 1758–1764) The steel is hardened by precipitation of M_6C, this and $Cr_{23}C_6$, Fe_2Mo, Fe_2W, and σ-phase were observed and increase with higher ageing temp., fall in C and rise of Mo and W. Mo and W increase susceptibility to oxidation in air at 1100°C. Tensile strength is increased linearly by Mo or W, also creep-rupture strength and this was higher with high C.

Properties of some precipitation-hardening stainless steels and low-alloy high strength steels at very low temperatures J. E. Campbell and L. P. Rice (*ASTM STP*, 1960, (287), June 30, 158–167) The cryogenic properties of materials have assumed great importance since the development of the liquid fueled rocket engine as a prime propulsion system. This paper contains data on the cryogenic properties of several precipitation hardening stainless steels and high-strength low-alloy steels from room temp. to −423°F.

Low-temperature properties of cold rolled AISI types 301, 302, 304 ELC and 310 stainless steel sheet J. F. Watson and J. L. Christian (*ASTM STP*, 1960, (287), June 30, 170–193) In this investigation the mechanical properties were determined at 78, −100, −320, and −423°F. The alloys were studied in a variety of cold-worked tempers in thicknesses varying between 0·013 and 0·032 m. The alloys were tension tested in both smooth and notched configurations to provide values of yield and tensile strength elongation, notched unnotched tensile ratios in the base metal, and tensile strength and elongation in heliarc butt-welded joints.

Self diffusion in iron F. S. Buffington, K. Hirano, and M. Cohen (*Acta Met.*, 1960, **9**, May, 434–439).

Self-diffusion in iron and in its alloys with aluminium in the high-temperature delta-range S. D. Gertsriken and M. P. Pryanishnikov (*Issledovaniya po zharoprochnym splavam*, Moscow, 1960, **6**, 95–98).

Diffusion of nickel into iron K. Hirano, M. Cohen, and B. L. Averbach (*Acta Met.*, 1961, **9**, May, 440–445) The diffusion of Ni into iron was measured in the temp. range 600–1050°C. Radioactive ^{63}Ni was used as the tracer element; the surface-decrease and the residual-activity sectioning methods were employed. The diffusivity below the Curie temp. was observed to be lower than that expected from the extrapolation of the diffusion data for paramagnetic alpha-iron. The diffusion coefficient may be expressed as follows (in cm²/sec); Gamma iron $D=0·77 \exp(-67000/RT)$; Paramagnetic alpha-iron above 800°C, $D=1·3 \exp(-56000/RT)$; Ferromagnetic alpha-iron below 680°C, $d=1·4 \exp(-58700/RT)$. The anomalous decrease in the diffusion coefficient starts at about 800°C, somewhat above the Curie temp. and is thought to be associated with the effect of short-range magnetic order on the formation energy of vacancies.—S.H.-S.

Effect of chromium content on diffusion rate and solubility of hydrogen in alloys of iron with chromium V. A. Yagunova, K. V. Popov, and K. P. Zhdanova (*Issledovaniya po zharoprochnym splavam*, Moscow, 1960, **6**, 231–237) Rate of penetration of H_2 through metal plates in the electrolytic method of saturation in a normal solution of H_2SO_4 with an accelerating addition of As at a current density of 0·74 cm² is determined by the diffusion rate of H_2 in solid solution. An increase in Cr content in Fe–Cr alloys significantly reduces the diffusion rate of H_2, and the effect of Cr has a particularly large effect at small concentrations, e.g. up to 1%. Other results are given.—A.I.P.

Concerning the effect of crystal structure defects of different degrees on the mobility of atoms in nickel and iron alloys I. Ya. Dekhtyar and V. S. Mikhalenkov (*Issledovaniya po zharoprochnym splavam*, Moscow, 1960, **6**, 120–129).

On the diffusion of cobalt, chromium and tungsten in iron and steel P. L. Gruzin ('*Problems of Metallography and the Physics of Metals*', ed. B. Ya. Lyubov, English translation, NY, 1959, 329–336) The temp. dependence of the diffusion coefficients of Co, Cr, and W in the α- and γ-phases of technical iron and C-steel of eutectic composition were examined in a temp. range 700–1250° using ^{51}Cr, ^{60}Co, and ^{185}W. An analysis of the data on the diffusion of many metallic systems enables the conclusion to be drawn that at the m.p. the diffusion coefficients are equal to each other not only in the case of the readily melted nonferrous metals and alloys but also in the case of metals of the Fe-group. These findings are discussed.—C.V.

The problem of studying diffusion by the method of radioactive isotopes P. L. Gruzin and P. L. Litvin ('*Problems of Metallography and the Physics of Metals*', ed. B. Ya. Lyubov, English translation, NY, 1959, 337–342) Isotopes of many elements emit β- and γ-rays. If such an isotope is deposited on the specimen and this is diffusion annealed, the relation of the β-radiation intensity to that of the γ-radiation will be decreased. These latter rays are only slightly absorbed in the diffusion layer and their intensity is almost unchanged even with a prolonged anneal while the β-radiation (because of the greater absorption by the specimen) is considerably decreased. Specimens were Fe plates 3×12×25 mm were used, subjected to a preliminary homogenizing anneal at 1050–1250° and covered with a layer of ^{60}Co to a thickness of 1 μ; and Al-filter was used and the intensity of radiation with, and without the filter gave the intensities of the β- and γ-radiations separately. The details of this, and further experimentation, are given and discussed.—C.V.

Influence of intra-grain structure of austenite on the self-diffusion of iron P. L. Gruzin, E. V. Kuznetsov, and G. V. Kurdyumov ('*Problems of Metallography and the Physics of Metals*', ed. B. Ya. Lyubov, English translation, NY, 1959, 343–345) Studies of the diffusion of Fe, Fe–Ni, and Fe–Ni–C alloys show that the exponential dependence of D on temp. does not hold throughout the whole range. The straight line shows a break at 1000–1100° and the inclination of this curve below has a lower value than that above this point. This break is absent in high C-alloys which do not undergo martensitic transition on cooling to room temp. The specimens examined were (a) 19·8%Ni, 0·45%C; (b) 24·6%Ni, 0·69%C. Preliminary annealing to stabilize the austenite grains was at 1330° for 5 h and after cooling the specimens had austenitic structure at room temp.; to produce martensite, cooling in liquid-N_2 was resorted to. Diffusion coefficients were determined at 900, 950, 1000, and 1100°. The results obtained are examined.—C.V.

Influence of carbon on the self-diffusion of iron in the system iron–nickel P. L. Gruzin ('*Problems of Metallography and the Physics of Metals*', ed. B. Ya. Lyubov, English translation, NY, 1959, 346–349) In the examination of this system it was concluded that C weakens the binding forces of the atom not only in the γ-Fe but also in the solid solutions of a binary Fe–Ni-alloy. The influence of C on the parameters of self-diffusion in these binary alloys decreases with increase of Ni content.—C.V.

Influence of manganese on the self-diffusion of iron P. L. Gruzin, B. M. Noskov, and V. I. Shirokov ('*Problems of Metallography and the Physics of Metals*', ed. B. Ya. Lyubov, English translation, NY, 1959, 350–354) It is shown that both in volume of self-diffusion and in self-diffusion between crystallites, there is an increase in activation energy with increasing concentration of Mn in the alloy up to 4%, but a further increase to 8% brings about a decrease in the D_0 and Q values. Assuming that the ratio of activation energy to binding energy has the same value for alloys as for pure Fe, the addition of Mn can lead to a considerable increase in the binding energy of the lattice.—C.V.

The use of the artificially radioactive isotope ^{14}C for the study of the diffusion of carbon in steel V. G. Kostogonov, P. A. Platonov, and P. L. Gruzin ('*Problems of Metallography and the Physics of Metals*', ed. B. Ya. Lyubov, English translation, NY, 1959, 361) (*Proc. Acad. Sci. USSR*, 1955, **100**, 1069).

Influence of chromium on the self-diffusion of iron P. L. Gruzin ('*Problems of Metallography and the Physics of Metals*', ed. B. Ya Lyubov, English translation, NY, 1959, 362–364).

A study of the self-diffusion of α-iron V. M. Golikov and V. T. Borisov ('*Problems of Metallography and the Physics of Metals*', ed. B. Ya. Lyubov, English translation, NY, 1959, 365–376) The two methods for determining diffusion coefficients by means of radioactive isotopes are discussed and compared: (a) those involving destruction of the structure of the diffusion layer, and (b) the ones based on the absorption of radiation by the substance. The 'a' group is not very suitable for a study in the α-phase but those in 'b' possess a number of advantages and experimental procedure is not complicated. The temp. dependence of the coefficient of self-diffusion of α—Fe has been determined over the range 650–850° and the activation energy is 67100 cal/mol.—C.V.

Investigation of the diffusion of cobalt and iron along grain boundaries S. D. Gertsriken, T. K. Yatsenko, and L. F. Slastnikova (*Issledovaniya po zharoprochnym splavam*, 1959, **4**, 152–157).

Investigation into the effect of silicon on the diffusion of aluminium into iron S. Gebalski and A. Zdanowski (*Prace Inst. Mech. Prec.*, 1960, **8**, (29), 57–63).

Experimental determination of charge components in heat-resisting alloys of the Fe–Al system P. P. Kuzmenko and E. I. Khar'kov (*Issledovaniya po zharoprochnym splavam*, Moscow, 1960, **6**, 112–119).

The influence of subcooling on the fluidity of molten metals S. Morita (*Giesserei Techn.-Wiss. Beihefte*, 1961, **13**, April, 109–122) A study of the effects of C, Si, and P on the fluidity of cast iron and the fluidity of Ti- containing cast iron and S–H-cast iron is reported. The influence of the subcooling factor is also investigated and its causes determined. Nonferrous cases are also included (55 refs).

Hydrogen in steel and its effects P. Bastien (**ATB Met.*, 1958, **1**, (51), 127–138).

Trapping of hydrogen in cold worked steel H. H. Podgurski (*Trans. Met. Soc. AIME*, 1961, **221**, April, 389–394) Above 200° the observed increase in the apparent solubility of H_2 in low-alloy steels caused by cold work is attributed to the formation of CH_4 in the microvoids, and this can be isolated quantitatively. The amount is in accordance with the equilibrium $2H_2+Fe_3C=CH_4+3Fe$. The microvoid volume, calculated from the CH_4 content, corresponds approximately to that calculated from the measured density decrement produced by cold work.—C.V.

The influence of hydrogen on the long-time strength of certain steels N. P. Chernykh, V. D. Molchanova, and M. I. Mil' (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5**, 98–406) The long-time strength of hollow test-pieces made from steels EI579, EI579B, and 30KhMA tested by internal H_2 pressure is lower than long-time pressure under N_2 pressure, and this difference increases with an increase in the time taken for the test.

Solubility of nitrogen in liquid iron-manganese alloys R. A. Dodd and N. A. Gokcen (*Trans. Met. Soc. AIME*, 1961, **221**, April, 233–236).

Recent experiments on stabilized and non-stabilized, acid resistant austenitic steels H. Krainer (*Berg. Hütten. Monatsh.*, 1960, **105**, Nov., 280–291) The influence of various elements on grain boundary failure of austenitic Cr–Ni steels and on stress corrosion cracking in boiling 42%$MgCl_2$ are discussed. The effect of oxygen, oxides, and nitrogen are dealt with.

Review of a book by V. S. Mes'kin: 'Principles of the alloying of steel' A. P. Gulyaev, V. A. Delle, S. F. Yur'ev, A. M. Bordyka, and N. F. Vyaznikov (*Stal'*, 1961, (5), 454–455) The book is very favourably reviewed.

Solubility limit of certain alloying admixtures in steel N. S. Fastov and B. N. Finkelshtein ('*Problems of Metallography and the Physics of Metals*', ed. B. Ya. Lyubov, English translation, NY., 1959, 200–204) A V-alloyed steel is used this being basically a three-component system (Fe, C, and V), and in this system two phases will be formed after isothermal soaking, these being in equilibrium with each other. A series of equations are evolved giving the total

number of C-, V-, and Fe-atoms in the whole system in the first and second phase; from these it is possible to determine not only the solubility of V and the amount of V-carbide in steel but also the analogous concentrations of other alloying additions.—C. V.

Effect of carbon, silicon and phosphorus on tensile and impact properties of ferritic black-heart malleable iron C. T. Moore (*BCIRA J.*, 1961, **9**, May, 385–405).

Aluminium and nitrogen in steel (*Mech. World*, 1960, **140**, Sept., 367–368).

Effect of chromium on the binding forces in α-iron crystals V. K. Kritskaya, G. V. Kurdyumov, and T. I. Stelletskaya ('*Problems of Metallography and the Physics of Metals*', ed. B. Ya. Lyubov, English translation, NY, 1959, 281–283).

Steel plus uranium: what's the result? S. L. Gertsman (*Can. Metalw.*, 1961, **24**, March, 36–37) If U has to produce the same properties as other known additives to justify its use it must either lower the cost or produce a still better effect. The addition of 0·32% has no observed effect on hardenability; at 0·7% there is an effect but one can be produced more cheaply by normal alloying agents. However, a quite marked decrease in corrosion rate is noted using 0·07–0·23%U, and the fatigue strength of plain C-steels is considerably increased. The cause is as yet unknown but the high affinity to U for 0, N, C, S, and B is well known and further work upon this problem is being continued which includes cast iron, Cu-, Al-, Mg-, and Zn-based alloys.—C. V.

Influence of certain elements on the properties of irons R. Barton (*Fonderia*, 1961, **10**, (4), 183–185) [In Italian].

Effect of alloying admixtures on the temperature dependence of the shear modulus of iron N. S. Rysina and B. N. Finkelshtein ('*Problems of Metallography and the Physics of Metals*', ed. B. Ya. Lyubov, English translation, NY, 1959, 289–293).

Cast austenitic steels for use at a temperature of 650–700°C G. P. Fedortsov-Lutikov, F. I. Pashukanis, and M. I. Solonouts (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5**, 166–172) Fourteen steels were investigated, of which only four were found to be satisfactory: (a) 17%Cr 12%Ni 1%Nb, (b) 17%Cr 12%Ni 1%Nb+3%W, (c) 17%Cr 12%Ni 1%Nb+6%W, (d) 17%Cr 12%Ni 1%Nb+3%W+1%Mo+0·15%Ti. The first two were satisfactory in casting properties, but, being single phase, exhibited poor weldability. The casting properties and weldability of the last two steels were completely satisfactory for the manufacture of fittings and cast parts of steam power plants working at 660°C and a pressure of 300 atm, and also for parts of gas turbines with a working temp. of 700°C.

Austenitic steel grade EI 726 K. A. Lanskaya, R. M. Kireeva, and E. N. Gorchakova (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5**, 19–24) The Cr–Ni–W–Nb steel with boron grade EI 726 is one of the most heat-resisting steels of the austenitic class. The high heat-resisting properties are obtained by alloying with W, Nb, B, and Ce. The simultaneous introduction into Cr–Ni–B steel of additions of B and Ce increases long-time strength to a greater degree than the introduction of each element separately. 0·025%B and 0·02%Ce are introduced. Ca is best used only as a deoxidizer.—A.I.P.

Stainless steel (*Product Fin.*, 1961, **14**, April, 72–75).

An investigation of the properties of steel EI 756 G. P. Fedortsov-Lutikov, M. F. Sheshenev, R. C. Kaplan, N. I. Butko, and L. S. Marinenko (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5**, 160–165) Results are presented of the introduction into production of forgings made from chromium steel EI756 used for the rotors of steam turbines. The steel has high heat-resisting properties and they are almost completely unrelated to the way in which the test-pieces are cut (radial or tangential).—A.I.P.

Heat-resisting chrome–nickel–titanium steels EI696 and EI696A F. F. Khimushin, Z. A. Shevankova, G. E. Moskalenko, N. K. Kernich, and B. E. Lyubinskii (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5**, 25–31) A study of the effect of alloying on the heat-resisting properties of iron-based alloys and the use of cleaner charge materials has made it possible to develop a highly heat-resisting steel for high temp, which has found wide application in the manufacture of a large number of parts for gas turbines. Properties are given.—A.I.P.

High-strength medium alloy steel takes heat (*Steel*, 1961, **148**, May 1, 60–61) The composition and properties of Alloy BB, developed by Armour Research Foundation of Chicago, are presented with tabulated data on both sheet tensile and round tensile tests.—S.H.-S.

Precipitation hardening stainless steel R. Oppenheim (*DEW-Techn. Ber.*, 1961, **1**, April, 48–62) The alloying composition, the effective hardening processes, and the hardness values achieved at room temp., elevated temp., and low temp. of martensite, austenitic–martensitic, austenitic, and ferritic–austenitic steels, which undergo precipitation hardening, are discussed. Special attention is paid to the second and third types, which represent the stainless steels (29 refs).—M. L.

Precipitation hardening stainless steels J. Pitaud (*Rev. Nickel*, 1960, **26**, May–June, 71–76) [In French].

Nickel–chromium 18/8 stainless steel at the 2nd International Exhibition of 'Expomat 60' buildings B. de Borde (*Rev. Nickel*, 1960, July–Aug., 101–106).

9 percent nickel steel for low-temperature service International Nickel Co. Inc. (*Inco-Mond Mag.*, 1961, (17), 10–12) Work in the USA has shown that this 9%Ni steel is very suitable for low-temperature service; the cost of such pressure vessels is ~15% cheaper than fabricated vessels. Impact tests on three rectangular tanks at −196° and pressure tests on nine cylindrical vessels showed conclusively that stress relief was not required after fabrication. Details are given of various tests.

An advanced austenitic steel for high temperature steam conditions W. H. Bailey and G. T. Harris (*Brit. Electric & Allied Ind. Res. Assoc.*, J/E/T 217; 32–42; International Discussion on Long-Time Performance of High Temperature Steels, Düsseldorf, June 1960, Paper 28) G18B is basically Ni13, Cr13, Co alloy 10%. This is compared with types 316 and 347. The heat-treatment of G18B is discussed and the creep results are examined at some length. The size effect on forgings is investigated and for sizes up to 22in dia. there is no serious drop in properties and in the creep strength of a rotor normally lies within the scatter-band of strength that one might expect in bar material and the mechanical properties of a typical rotor forging of 23in dia. show good uniformity including core ductility. With smaller components, ageing or warm working may be used to raise the room temperature proof stress; this is not normally carried out with larger components although the effect of ageing is important in its connexion with stress relieving treatments after welding. When using this material for steam pipes and similar products, the solution treated condition and effects of stress relief must first be considered.—C. V.

A new nitriding steel for structural hardening W. S. Mounce and A. J. Miller (*Rev. Nickel*, 1960, **26**, Nov.–Dec., 163–166) [In French] Fundamental research into the role of Ni and Al as structural hardening agents has led to the discovery of a new steel which after structural hardening treatment between 500° and 570° has a rupture point of over 140 kg/mm. Nitriding treatment carried out in the same temp. range results in the formation of a nitrided surface equivalent to that obtained on Nitralloy type steels. This steel containing 5%Ni and 2%Al has an exceptional fatigue and wear resistance at atmospheric as well as high temp.

Manganese alloys H. Willners and K. A. Ottander (*Jernkont. Tek. Rad.*, 1954, **18**, (199), 123–166).

Design information on 5Cr–Mo–V alloy steels. (H–11 and 5Cr–Mo–V Aircraft steel) for aircraft and missiles (Revised) R. J. Favor and W. P. Achbach (*PB* 151072–R [Aug. 59], rev. Sept. 60, pp.51; *DMIC rept.* 116R; from *US Res. Rep.*, 1961, **35**, Feb. 10, 199).

New tool steel combines high strength, shock resistance Carpenter Steel Co. (*Mat. Design. Eng.*, 1961, **53**, April, 17).

Non-magnetic steels for high applied mechanical stresses M. Kroneis and R. Gattringer (**Stahl Eisen*, 1961, **81**, March 30, 431–445) Steels of this type are austenitic, precipitation-hardening steels of the Mn–Cr–V–N class. Austenitic steels for cold working are of the Mn–Cr and Mn–Cr–Ni type. The results of structure investigations are reported, they are supplemented by fatigue and notch-impact tests. In the discussion, the notch sensitivity of austenitic steels is mentioned.—T. G.

The Institute for material testing at the Technical University in Stuttgart K. Wellinger and D. Uebing (*Materialpruf.*, 1961, **3**, May 20, 190–197).

Effects of niobium on the properties of aluminium-killed medium-carbon steel E. E. Fletcher, A. R. Elsea, and E. C. Bain (*Trans. ASM Quart.*, 1961, **54**, March, 1–11) The effects of adding 0·012, 0·09, 0·17, and 0·35 Nb to a 0·35 C steel were studied and found to raise the yield and tensile strengths by as much as 8200 psi without loss in elongation or reduction in area. The greatest strength was obtained with a niobium content of only 0·012%. For all but one condition of heat treatment studied, Nb either lowered the notched-bar impact-transition temp. or had no appreciable effect on it, steels with 0·09%Nb or less showing a small degree of temper-brittleness.

Effect of addition of titanium on the properties of 18Cr–12Ni austenitic stainless steel R. Nakagawa and Y. Otoguro (*Rep. Nat. Res. Inst. Metals*, 1960, **3**, Oct., 260–268; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 595) [No abstract].—C.F.C.

Effect of V on properties of high C–5Cr–W–Mo, high C–8Cr–W–Mo and high C–12Cr–Mo steel for punching dies S. Koshiba and A. Inata (*Tetsu-to-Hagane*, 1960, **46**, Dec., 1772–1776) Up to 5%V was used. Good properties compared with high-C Cr steel were attained.

Effect of V, Al, and Zr on the properties of 18Cr–12Ni austenitic stainless steel R. Nakagawa and Y. Otoguro (*Tetsu-to-Hagane*, 1960, **45**, Sept., 1411–1414) The effects of Zr, V, and Al on tensile strength and elongation and on creep rupture time are described and illustrated.

The influence of rare-earth elements and compounds on steel D. L. Eppelseimer and S. D. Sehgal (*Trans. Indian Inst. Met.*, 1960, **13**, Sept., 265–276) The addition of rare earth oxides, fluorides, and LanCerAmp to experimental HF melts of low alloy steels caused desulphurization, minimized the size of inclusions, and improved their distribution. The oxides and LanCerAmp refined the grain size but the fluorides increased the grain size.

The evolution of ordinary and special steels in France P. Bastien (*Arts et Manuf.*, 1960, (104), Dec., 50—3).

Influence of melting atmospheres on austenite stability and mechanical properties of 18–8 stainless steels M. Okamoto, R. Tanaka, and R. Ito (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1405–1407) A graph shows the differential dilatation curves of 18–8 stainless steels. The effect of cold rolling sub-zero rolling and subsequent ageing at 300°F for 8 h on the hardness of 18–8 stainless steels is also shown.

High-strength steel sheet (300 M) J. C. Chang, F. J. Herr, and J. W. Sweet (*J. Met.*, 1960, **78**, Dec., 101–104) The results are reported of tests on basic electric and vacuum induction melted sheet and thin plate, heat-treated to 270000 psi. The sheet retained 7% elongation at sub-zero temp. and 230000 psi at 600°F.

Properties of certain cold-rolled austenitic stainless sheet steels R. J. Mangone, D. B. Roach, and A. M. Hall (*US OTS DMIC Rep.* 113, 1959, May 15, 1–10) A report on the physical and mechanical properties of five cold-rolled austenitic stainless steels AISI Type 301; MicroMach; AISI Type 201; USSS Tenelon; USS 17–5 MnV. These steels are employed or are under consideration for aircraft applications, and, in the full-hard condition, have yield strengths in excess of 150000 psi with ductilities of about 10%. They can be welded readily, but the welding heat destroys

the strengthening effect obtained by cold rolling.—S.H.-S.

A new nickel–cobalt–molybdenum plate steel International Nickel Co. (*Cobalt*, 2961, **11**, June, 38).

Springs in special steels (*Aciers Fins. Spéc.*, 1960, Dec., **36**, 58–85).

Factors affecting the ductility of iron–chromium–aluminium alloy sheet R. W. Endebrock, E. L. Foster jun., and R. F. Dickerson (*Battelle Mem. Inst. Rep. No, BMI*–1450, 1960, July 7; UC–25 Metallurgy and Ceramics (*TID*–4500, 15th ed.), 1–24).

METALLOGRAPHY

Non-destructive metallography P. A. Jacquet (*Metalloberfläche*, 1960, **14**, Dec., 368–369) The method involves electrolytic polishing followed by taking a lacquer impression of the surface. The impression is then examined microscopically. For high magnifications, the impression is treated in vacuum with Al and Au.—R.P.

An evaluation of procedures in quantitative metallography for volume-fraction analysis J. E. Hilliard and J. W. Cahn (*Trans. Met. Soc. AIME*, 1961, **221**, April, 344–352).

Simplified electron metallography of steels G. E. Pellissier (*ASTM STP*, 1960, (262), 32–56).

Electron metallography of neutron-irradiated steels R. F. McCartney and P. S. Trozzo (*ASTM STP*, 1960, (262), 63–72) The structure of irradiated and unirradiated USS T–1 constructional alloy steel, AISI type 347 stainless steel and ASTM A 201 carbon steel have been studied by electron metallography and the radiation induced changes in microstructure are described and interpreted. In the T–1 steel the carbide particle size and ferrite grain size are finer in the irradiated specimen while with the 347 stainless steel the intergranular precipitation of carbides during post-irradiation annealing is accelerated in the irradiated specimen. No observable changes were noted in the A 201 carbon steel as the result of irradiation.—C.V.

Electron microscopy of tin plate P. A. Stoll (*ASTM, STP*, 1960, (262), 73–76) Techniques are described for mounting and sectioning tin plate; these enable useful information to be obtained concerning its microstructure. An extension of this procedure may be useful in the investigation of other electro-deposited or hot dipped metal coatings.—C.V.

Structure-developments by means of interference vapour deposited films W. Pepperhoff (*Arch. Eisenh.*, 1961, **32**, April, 269–273) By vapour-depositing interference capable films of TiO_2 it was possible to 'develop' the structure of polished surfaces, circumventing the need for etching solutions. The process could be applied with success to various structures with two or more components, yielding equally clear contrast. The interference effect of the film enables detection of differentiation between structural components with a difference of only 2–3% in the reflection differences.

Non-metallic phosphorus inclusions in steel O. D. Moldavskii (*Stal'*, 1961, (5), 441–445) A study of the inclusions in steels of increasing P contents is reported. The phosphorus is found in solution in the Fe, as phosphides and phosphates, especially compounds of the type $(FeO)_n P_2O_5$.

Electron microstructure of the precipitation-hardenable austenitic and nickel-base alloys Sixth progress report of Subcommittee on Electron Microstructure of Metals, ASTM Committee E–4 on Metallurgy (*ASTM STP*, 1960, (262), 3–22) The research was designed to study methods of specimen preparation, replication and electron microscopic observation. The materials included two alloys which depend upon precipitation hardening for their mechanical properties above 1200°F. Specimens were prepared from Incomel X and W–545 and the report shows representative electron micrographs of the pre-heat treated structure of these alloys; the precipitate morphologies which are shown are interpreted and discussed and precipitate identification by electron diffraction and the electron microprobe techniques is partially completed and such findings are reported.—C.V.

Sulphide inclusions in steel L. H. Van Vlack, O. K. Riegger, R. J. Warrick, and J. M. Dahl (*Trans. Met. Soc. AIME*, 1961, **221**, April, 220–228) In resulphurized and plain-C steels at steel rolling temp., a liquid develops that is rich in O and Si. The composition varies as well as the resulting microstructures with the Mn/Si/O ratios of the steel and the liquid fluxes solid MnS. It is suggested that the liquid oxide–silicate phase facilitates the elongation of solid sulphide inclusions since solid MnS can be plastically deformed to a limited extent and the liquid which penetrates the boundary between the solid MnS and the solid steel provides a better opportunity for hydrostatic pressure during the rolling. The hot-shortness anomaly is explained by the resulphurized steel possessing sufficient solid MnS so that the sulphide is not completely fluxed by the oxide-silicate liquid. In plain-C steels, the sulphide may be completely fluxed unless sufficient Mn is present to keep the O-level low. Surface cracking may be aggravated by the oxidation of sulphide inclusions in the scale and in the sub-metal.—C.V.

Steel yields more of its secrets (*Mech. World*, 1960, **140**, Dec., 503–504) A general review of recent metallographic research.—C.V.

The use of electric heating in vacuo for the investigation of the microstructure and of the properties of a number of metals and alloys over a wide range of temperature M. Lozinskii (*IV Congres International d'Electrothermie*, Stresa, 1959, **I**, 254–262) [In English].

Microstructures and notes on carbon steels to B.S.3100:1957: 592 Grade C J. Turton and B. H. C. Walters (*Brit. Found.*, 1960, **53**, Nov., 480–482) Typical mechanical properties and microstructures of annealed and normalized cloverleaf test bars of 0·33%C steel.

Quantitative metallographic analysis of graphite size in ductile cast iron J. H. Brophy and M. J. Sinnott (*Trans. ASM Quart.*, 1961, **54**, March, 65–71).

Metallurgical research in the United States Steel Corporation. A lecture J. B. Austin (*NML Pilot Plant Symposium*, 1960, July, 296–298).

Combined platinum–carbon evaporation as a preparatory technique in electron micrography F. W. Günther and D. Raab (**Neue Hütte*, 1959, **4**, Feb., 113–115) A method of combined Pt–C evaporation is described in which the usual type of carbon electrode was replaced by a spectrographic carbon T2 of VEB Elektrokohle Lichtenburg (5 mm dia., 70 mm long). This made possible pre-shadowing for preparing specimens and heightened the contrast of the carbon replica. Figure 2 shows a nickel-oxide surface in which the specimen was pre-shadowed at 30° with platinum/iridium carbon and the film subsequently backed by evaporation at 90°. The nickel-oxide was obtained from a pure nickel specimen by thermal oxidation at 1400° for 2 h.—S.H.-S.

Transmission electron microscopy of dislocations in metals G. A. Geach and F. O. Jones (*AEI, Eng. Rev.*, 1961, **1**. March, 119–123).

A crystallographic survey of carbons E. G. Steward and B. P. Cook (*GEC J.*, 1960–61, **28**, Winter, 35–44).

Measurement of interlamellar spacing in pearlite B. Gregory, H. T. Hall, and G. Bullock (*Trans. ASM Quart.*, 1961, **54**, March, 106–110) The influence of the numerical aperture of the microscope objective on mean interlamellar spacing values obtained by the partial resolution technique has been examined, and values consistent with those obtained from 'two-surface' analysis have been obtained when the resolving power of the objective ($\lambda/2$ N.A.) is greater than the mean interlamellar spacing. The pearlite spacings in a eutectoid carbon steel have been measured and correlated with isothermal formation temp.

Methods of revealing austenite grain size G. Vigneron (*Mét. Corros. Ind.*, 1960, Dec., 439–454).

The plate-like non-metallic inclusions in steel. II. Behaviour of the plate-like inclusions during heating and in high carbon steel K. Matsubara and I. Hagiwara (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1357–1360) Tables show the chemical composition of specimens and the distribution of the inclusions in the ingot.

On a complex recrystallization texture in 3% silicon iron C. G. Dunn and C. J. McHargue (*J. Appl. Phys.*, 1960, **31**, Oct., 1767–1770).

Investigations on a high-temperature molybdenum–vanadium steel containing about 0·6% Mo and 0·3%V V. E. Baerlecken and H. Fabritius (*Brit. Electric & Allied Ind. Res. Assoc.*, International Discussion on Long-Time Performance of High Temperature Steels, Düsseldorf, June 1960, Paper 14).

Grain boundary segregation studies by activation W. W. Schultz (*ASTM STP*, 1959, (268), Oct. 13, 15–19) A new technique developed to gain information on the elemental structure of segregation at grain boundaries consists of activating the specimen and electropolishing the fractured surface in small increments. The fracture is along the grain boundaries. The induced activity of the dissolved metal in the etchant gives a quantitative measure of the elements present. The technique should be equally applicable to the study of the diffusion of one element into another or to the study of surface phenomena.

Evidence of impoverished zones of chromium accompanying intergranular precipitation of chromium carbide in an austenitic stainless steel J. Voeltzel and J. Plateau (*Compt. Rend.*, 1961, **252**, May 3, 2705–2707) The sensitivity to intergranular corrosion of 18–8 stainless steels which appeared after tempering at between 600 and 900°C is often attributed to the existence, in the neighbourhood of the joints, to a zone impoverished in Cr which would be the result of intergranular precipitation of chromium carbide. It is not possible, after the customary thermal treatment, to present evidence of this impoverishment by means of the micro-probe, but it is not surprizing if it only affects a narrow zone; the precipitations are not exactly localized in the surface of the joint and certain of them are apparent in the result provided by the microprobe.

On the crystallography of martensite: the '225' transformation in alloys of iron C. M. Wayman, J. E. Hanafee, and T. A. Read (*Acta Met.*, 1961, **9**, May, 391–402).

The effect of orientation on the recyrstallization kinetics of cold-rolled single crystals W. R. Hibbard jun. and W. R. Tully (*Trans. Met. Soc. AIME*, 1961, **221**, April, 336–343) Single crystals of Cu and Si–Fe were cold-rolled in an orientation chosen to produce individually the major components of the polycrystalline deformation texture, and the orientation dependence of the recrystallization kinetics was studied in relation to the primary recrystallization textures of the specimens. Rationalization of the polycrystalline recrystallized texture of this basis was not possible but the results suggest that the interaction of adjacent crystals during the deformation of the aggregate plays an important role.

On secondary recrystallization in high purity alpha iron C. G. Dunn and J. L. Walter (*Trans. Met. Soc. AIME*, 1961, **221**, 413–414).

Diagram of isothermic transformation of some Swedish Standard tough tempering steels G. Molinder (**Jernkont. Tek. Rad.*, 1959, **20**, (255), 405–530).

Diagrams for isothermal transformation of some Swedish Standard case hardening steels G. Molinder (**Jernkont. Tek. Rad.*, 1960, **20**, (260), 711–722).

Diagrams of isothermal transformations for martensitic stainless steels adopted as a Swedish Standard G. Molinder (*Jernkont. Tek. Rad.*, 1961, **20**, (261), 723–732).

The transformation behaviour of 50 Cr V 4 steel K. Bungardt, H. Preisendanz, and H. Brandis (*Arch. Eisenh.*, 1961, **32**, April, 261–268) Hardening and transformation behaviour study of 50 Cr V 4 steels by means of frontal quenching and of time-temp. transformation diagrams was performed. The varied behaviour is explained on the nucleation state of the material, which is determined by the initial structure and the austenitization conditions.

The effects of molybdenum, tungsten and copper on the solubility of graphite in liquid iron and a method for calculation of the activity coefficient of carbon in multicomponent alloys T. Mori, K. Aketa, H. Ono, and H. Sugita (*Mem. Fac. Eng. Kyoto. Univ.*, 1960, **22**, Oct., 410–421) [In English].

Study by continuous calorimetry of eutectic

fusion in the iron–carbon system M. Genot (*Compt. Rend.*, 1961, **252**, April 24, 2520–2522).

Diagrams of isothermal transformation valid for some Swedish standardised instrument steels G. Molinder (**Jernkont. Tek. Rad.*, 1954, **18**, (203), 263–290).

Kinetics of thermally-activated transformation in S.G. iron J. H. Gittus (*Iron Steel*, 1961, **34**, April, 124–139) The effects of heat-treatment and composition on the following reactions have been studied: (1) γ+cementite→γ+graphite; (2) γ→martensite, bainite, pearlite (α+graphite); (3) pearlite, bainite, martensite α+graphite; (4) temper-embrittlement and temper toughening; and (5) precipitation hardening. Reaction (1) was accelerated by Mg and retarded by S while (2) was controlled by the major alloying elements (Ni, Mn, Cr, Mo) and (3) was retarded by traces of Sn, Cu, and accelerated by grain refinement. Embrittlment took place at a higher temp. than toughening and both were time-dependent; in (5) this state was induced by Ni and Al.—C.V.

The effect of plastic deformation and strain ageing on the transition temperature of mild steel T. R. G. Williams and D. H. Hughes (*Metallurgia*, 1961, **63**, May, 233–237) The results of measurements of the transition temp. of mild steel by means of the Tipper test are presented and claimed to be at variance with published information on notched impact tests. The role of Cottrell locking effects in the brittle behaviour of mild steel at low temp. is minimized.—S.H.-S.

An investigation of phase transformations in alloys of iron–vanadium and iron–chromium M. I. Zakharova, M. N. Ignatova, L. N. Semenova, and N. A. Khatanova (*Issledovaniya po zharoprochnym splavam*, 1959, **4**, 263–265).

Laws of the thermal-kinetic transformation of austenite and the problem of designing alloys P. V. Romanov (*Issledovaniya po zharoprochnym splavam*, Moscow, 1959, **5**, 137–142) Systematism is suggested for binary alloys according to types of equilibrium diagrams. Generalized diagrams have been constructed of the states describing the behaviour of alloys during equilibrium and non-equilibrium cooling (6 refs).—A.I.P.

The austenite solidus and revised iron–carbon diagram M. G. Benz and J. F. Elliot (*Trans. Met. Soc. AIME*, 1961, **221**, April, 323–331).

On the processes of carbide formation in isothermal decomposition of alloyed austenite R. I. Entin ('*Problems of Metallography and the Physics of Metals*', Consultants Bureau, Inc., NY, 1959, 156–164) In Mo alloyed steel (0·68%C, 0·65%Mo) and equilibrium carbide $(Fe, Mo)_{23}C_6$ containing 2–3%Mo is formed even in the initial stages of decomposition in the temp. range Ac_1 and 590 while cementite is formed in the intermediate transformation temp. range. With a Cr-steel (0·4%C, 4%Cr or 0·4%C, 8·5%Cr) trigonal carbide $(Fe, Cr)_7C_3$ occurs with a Cr-content >35% at a temp. interval Ac_1 to 550° during the initial stage of the austenite decomposition; in the intermediate temp. range cementite is formed with a Cr-content equal to that found normally in steel. The experimentation is described.—C.V

Effects of elements forming difficulty soluble carbides on the decomposition of austenite L. I. Kogan and R. I. Entin ('*Problems of Metallography and the Physics of Metals*', Consultants Bureau, Inc., NY, 1959, 165–178) Alloying C-steels with Ti, V, Zr, Nb, or Ta leads to the formation of very stable carbides which do not transform into austenite when heated to 900–1000°; therefore the speed of austenite decomposition is not only not reduced but it is increased. Partial transition of these carbides into austenite at this temp. can be achieved by alloying with Mn (1·5–2·5%); to a lesser extent this is also achieved with Cr and Cr–Mn steels. Upon subsequent decomposition of austenite containing such strongly-carbide-forming elements it gives cementite enriched with these elements in the pearlite range.

Investigation of the distribution of chromium and tungsten during the decomposition of austenite using the radioactive tracer method S. V. Tsivinsky, L. I. Kogan, and R. I. Entin ('*Problems of Metallography and the Physics of Metals*', Consultants Bureau, Inc., NY, 1959, 185–199) Decomposition of alloyed austenite in the pearlite range of temp. is produced by the need of diffusion redistribution of the alloying carbide-forming elements (Cr or W) and during the process of isothermal decomposition the relative concentration of these elements in the carbide phase varies little. The influence of the secondary redistribution begins to manifest itself only after the end of the austenite decomposition. The need for diffusion redistribution of these alloying carbide elements in the austenite causes a considerable reduction in the speed of decomposition in the pearlite range. For steels with a higher Cr-content the speed of the $\gamma<\alpha$ transformation may play an important role. ^{51}Cr and ^{185}W were used.—C.V.

Effect of cooling conditions on the kinetics of the martensitic transformation O. P. Maksimova and E. G. Ponyatovsky ('*Problems of Metallography and the Physics of Metals*', Consultants Bureau, Inc., NY, 1959, 123–133) A thermomagnetic method was used with a Fe–Ni 22·4–Mn 3·4–C 0·04%-alloy possessing a martensitic point of $T_m = -30°$. Pre-supercooling of the austenite gives a more intense martensitic transformation this being the degree and speed of the pre-cooling; the transformation range is also expanded. Despite these observations, pre-supercooling scarcely affects the final martensitic transformation. The role of the stresses that activate the transformations are discussed.—C.V.

The effect of hot plastic deformation on the kinetics of the martensitic transformation in high nickel steels O. P. Maksimova, A. I. Nikonorova, and G. K. Pogorelov ('*Problems of Metallography and the Physics of Metals*', Consultants Bureau, Inc., 1959, 134–137) Four steels (C 0·51, 0·80, 0·55, 0·76%; Ni 16·9, 15·0, 24·2, 22·0%) were examined. A study was made of the effect of heating temp. during hardening on the behaviour of austenite at subsequent deep cooling and the behaviour of the different types of steel to heating, annealing, and forging is described. The change in stability of austenite caused by forging is analogous to the changes found in high-Ni austenite steels subjected to cold plastic deformation accompanied by a large degree of reduction. This highly elastic austenite may experience deep structural changes during the deformation at a temp. somewhat above the recrystallization temp. and possibly due to fragmentation of the crystals leading to distortion of the crystal lattice.

Phenomenon of stabilization in reverse martensitic transformation Y. M. Golovchiner and Y. D. Tyapkin ('*Problems of Metallography and the Physics of Metals*', Consultants Bureau, Inc., NY, 1959, 141–147) Two Fe–Ni alloys (N27 27%Ni; N27T 27%Ni, 1·5%Ti) were examined; these undergo reverse martensitic transformation, $\alpha\rightarrow\gamma$, when heated to suitable temp. Two methods were used, X-ray diffraction and magnetic, but with this latter, observations were complicated by the fact that in both these alloys the low temp. α-phase and the high temp. γ-phase are ferromagnetic, and a special procedure had to be adopted. The experimentation is described, heating being carried out in an ordinary electric tubular oven in air and in a lead bath; the results are compared. The γ-phase is less stabilized in the lead bath than in air. The most probable cause of increased stability of the γ-phase in the reverse martensitic transformation is the change in the state of its crystal lattice. This is discussed in some detail.—C.V.

The state of martensitic crystals in technical iron and in low-carbon steel after hardening G. K. Kurdyumov, M. D. Perkas, and A. E. Shamov ('*Problems of Metallography and the Physics of Metals*', Consultants Bureau, Inc., 1959, 155) From *Proc. Acad. Sci. USSR*, 1953, **92**, 955.

Bainitic transformation of carbon-silicon steel J. Deliry, M. Wintenberger, and J. Pomey (*Compt. Rend.*, 1961, **252**, May 3, 2713–2715) In the isothermal bainitic transformation of 2%Si steel the ferritic platelets develop in contact with an austenite enriched in carbon. The carbon-supersaturated ferrite spontaneously rejects the ϵ-crabide. The quantity of ϵ-carbide contained by the bainite shows that the initial supersaturation of the α-phase increases with the fall of temp.; it tends towards the total carbon content of the steel at the M_s point.

Certain regularities in the formation of sigma phase in steel with 18%Cr and 14%Mn O. A. Bannykh and I. F. Zudin (*Issledovaniya po zharoprochnym splavam*, Moscow, 1960, **6**, 187–194) After water quenching of steel with 18%Cr and 14%Mn from 1 100°C, ferrite decay during tempering begins with the production of carbides which are located as short chains along the grain boundaries. The process of separation of the sigma-phase is accompanied by a significant increase in hardness (11 refs).

Effect of nickel and silicon on the eutectic carbon in cast iron R. D. Schelling (*Fond. Belge*, 1961, **31**, March, 63) A study, reproduced in two diagrams, has resulted in the following formula: C eutectic = 4·30–0·33 (%Si)–0·047(%Ni)+0·0055(%Ni) (%Si). This formula is only valid for cast irons containing a maximum of 37%Ni and 3%Si.—S.H.-S.

The iron–ruthenium alloys E. Raub and W. Plate (*Z. Metallk.*, 1960, **51**, Aug., 477–481).

On the reliability of the material strength of leaded alloy steels: Study of leaded free-cutting steels, 12 T. Araki, A. Koyanagi, and H. Ohashi (*Tetsu-to-Hagane*, 1960, **46**, Sept., 1379–1382).

The determination of transformation characteristics of steels [by a magnetic method] A. Szombatfalvy (*Koh. Lapok.*, 1961, **94**, April, 145–150).

Cooling transformation diagrams for A.I.S.I. 8620 and 8640 R. C. Hess and D. J. Blickwede (*Met. Prog.*, 1960, **78**, Dec., 100B).

Influences of carbon, silicon, manganese, phosphorus and sulphur on the S-curve in molybdenum copper cast iron Y. Tokunaga (*Imono*, 1960, **32**, Oct., 713–722) Irons with 0·4–0·6%Mo and 1·2–1·5%Cu austenitized at 900°C for 30 min showed small effects of C and Si; apart from shorter transformation times in the bainite range. P moves the S curve in the pearlite range to the left and in the upper bainite range slightly to the left. Mn restrains and S greatly accelerates the transformations.

The carbon content of low carbon martensite M. L. Verheijke (*Philips Res. Labs. Reprint*, 406, from *Res. Rep.*, 1960, **15**, Oct., 437–444) The carbon content of low carbon martensite can be determined from dilatometric experiments and resistivity measurements during the first stage of tempering. It was 0·3%.

New name for tempered martensite M. Káldor (*Koh. Lapok.*, 1961, **94**, March, 119) The author suggests the name 'spherodite'.

The distribution of copper between molten lead and carbon-saturated iron G. Urbain (*Arch. Eisenh.*, 1961, **32**, May, 303–304) [In German] Tests were carried out and the chemical analysis was made after the equilibrium had ceased to exist. The relation of the Cu content of the lead to that of the carbon saturated molten iron averaged 2·05.

Kinetics of formation of the iron–tin alloy, FeSn R. P. Frankenthal and A. W. Loginow (*J. Electrochem. Soc.*, 1960, **107**, Nov., 920–923).

CORROSION

Activities of the Corrosion Council K. Trägårdh (*TVF*, 1959, **30**, (5), 201–208) At the Council's Test Station on the west coast of Sweden six tests have been made of paint for heavy material. At the last, in 1958, different types were tested for method of and exactitude in application. A report 'Scale of Degrees of Rust . . . and Degree of Exactitude . . .' is available in English as also is one on the ten degree scale of painting. Other committees deal with branches of the subject, including metal coverings and non-ferrous metals.

Growth of single iron crystals for corrosion studies W. F. Brickell and E. C. Greco (*Corrosion*, 1961, **17**, May, 237t–238t) The authors describe a laboratory method of producing single iron crystals which have characteristic plane surfaces and essentially cubic dimensions. The crystals can be used for corrosion studies where various crystallographic planes are of interest.

Corrosion of alloy steels A. Foulon (*Metall.*, 1960, **14**, Oct., 1011–1012).

The causes of stress corrosion susceptibility in non-ferrous alloys and steels L. Graf

(*Korrosion*, **12**, 1960, 54–59) [In German].

Corrosion—the constant enemy G. H. Gates-Reed (*Iron Steel Rev.*, 1960, Tata No., 213–214) A brief survey.—S.H.-S.

A discussion of the mechanism of stress corrosion T, Mishima (*Kinzoku*, 1959, **29**, Oct., 741–746) In some metals cracks appear after a period of time in conditions under which corrosion is not normally expected to occur. Upon further examination, the material is found to be under tensile stress which has exceeded a certain critical value. This is stress corrosion. The author describes stress corrosion at length and accounts for the mechanism of this type of corrosion. His discussions are with special reference to corrosion in castings standing at room temp., which is described as 'season cracking'.

A [possible] corrosion-proof metal [car] body H. D. Van Sciver (*SAE J.*, 1961, **69**, March, 38–40).

Pretreatment is important! K. A. van Oeteren-Panhäuser (*Metall-Reinigung + Vorbehandlung*, 1960, **9**, Oct., 171–173).

The local corrosion of 18–8 stainless steel in the atmosphere M. Tagaya and S. Miyase (*Proc. 2nd Japan Congress in Testing Materials*, 1959, 120–122).

Corrosion of aluminium–nickel–iron alloys G. J. Biefer and F. H. Krenz (*Nat. Assoc. Corros. Engrs.*, 1960, Aug., 1–16).

Corrosion of metallic materials in high-temperature pile-irradiated water G. E. Galonian (*Nat. Assoc. Corros. Engrs.*, 1960, Aug., 34–45).

Corrosion of carbon and low-alloy steels in out-of-pile boiling-water-reactor environment D. C. Vreeland, G. G. Gaul, and W. L. Pearl (*Nat. Assoc. Corros. Engrs.*, 1960, Aug., 46–59).

Aluminium alloys for handling high-temperature water M. H. Brown, R. H. Brown, and W. W. Binger (*Nat. Assoc. Corros. Engrs.*, 1960, Aug., 82–96).

Stress corrosion A. Bassi, E. Brutto, G. Imarisio, G. Perona, and R. Sesini (*Energia Nucl.*, 1961, **8**, (5), 361–363) [In Italian] During operation, tubes in a heat exchanger were seen to have become defective due to stress corrosion. Tests proved that damage to austenite and carbide precipitation make stainless steel more prone to corrosion. It is certain that as a result of the partial boiling the concentration of ions, in all the cooling water present in the condenser was higher than the critical figure considered normal for the appearance of this phenomenon.

Investigations on the occurrence and growth of pitting locations H.-J. Engell and N. D. Stolica (*Korrosion* 13, 1960, 14–15; discussion 17–20) Current-time graphs were plotted at constant potential from experiments on passivated iron electrodes in Cl-containing $\mathrm{N}H_2SO_4$, and the time law for the formation of new pits established.

Pitting of chemically-resistant steels W. Schwenck (*Korrosion* 13, 1960, 20–27).

Penetration of chlorine ions through the passivated layers of austenitic 18–8 Cr–Ni steels H. J. Rocha (*Korrosion* 13, 1960, 28–33) Theory, experimental determination of penetration potentials in the regions of primary and secondary passive layers, and a comparison with the properties of Mo-containing austenitic steels (14 refs).

Pitting on steel for shipbuilding G. Becker and W. Dick (*Korrosion* 13, 1960, 35–39; discussion 45–48).

Pitting in tankers H. Determann (*Korrosion* **13**, 1960, 40–44; discussion 45–48) Examples of pitting corrosion in various parts of a tanker are given, and their causes and prevention discussed.

Pitting in heating systems and boilers H. Ladeburg (*Korrosion* 13, 1960, 44–45; discussion 45–48).

Pitting as a typical form of corrosion in nickel coatings A. Kutzelnigg (*Korrosion* 13, 1960, 64–65) A discussion, with reference to the literature (13 refs).

Pitting formation on hot dip galvanized steel articles W. Rädeker (*Korrosion* 13, 1960, 69–72; discussion 72–76) Experiments on hot-dip galvanized steel tubes, and comparative tests on black tubes, are described. It is concluded that pitting can occur on the galvanized tubes; that a subsequent heat-treatment which converts the Zn coating into an Fe–Zn compound increases susceptibility to pitting; that the number of pits in the latter case is less than in black tube, although their average depth is about the same; and that measures which improve resistance of the galvanized material to atmospheric corrosion (such as annealing in the range 600–700°C) do not produce a similar improvement in pitting resistance. Experiments are proceeding.

Structure of scale on plain carbon steels (*BISRA Summary*, 1961, **166**, April, pp.2) The nature of scale on hot-rolled steel strip is described, and a mechanism for its formation suggested, as it differs from normal high temp. scales, owing to the time-temp. histories of the strip. The removal of such scale, by mechanical treatment, followed by hot acid pickling is discussed.—A.W.D.H.

Mechanism of the oxidation of iron films at temperatures from −195°C to 120°C M. W. Roberts (*Trans. Farad. Soc.*, 1961, **57**, Jan., 99–109).

Solubility of oxygen in liquid iron–silicon alloys at atmospheric pressure and under vacuum conditions Hsu Tsê-chi, A. Yu. Polyakov, and A. M. Samarin (*Izvest. AN Otdel. Tekhn. Met. i Toplivo*, 1961, (2), 115–118) To establish the effect of pressure on the solubility of oxygen in liquid Fe–Si alloys experimental heats have been carried out in a resistance furnace with a graphite heater. Results of this earlier work are given and analysed.—A.I.P.

The behaviour of passive iron specimens in the presence of halogen ions K. G. Weil and D. Menzel (*Korrosion* 13, 1960, 12–13; discussion 17–20) Conditions necessary for the initiation of local attack by halogen ions, circumstances enabling the co-existence of apparently active locations and passive surfaces, and the cause of simultaneous deep and surface growth are examined.

Corrosion tests improve coatings C. F. Nixon (*SAE J.*, 1960, **68**, Sept., 60, 61).

On the corrosion and passivation of metals in the light of paper chromatographic electrophoresis J. Frasch (*Korrosion*, 12, 1960 59–68) [In German].

Contribution to the problems of the kinetics of metal dissolution I. Sekera (*Korrosion* 12, 1960, 45–47) [In German] The dependence of rate of dissolution on the rate of diffusion and discharge of H ions at various acid or alkali concentrations is discussed and activation energies for several metals and solutions at various concentrations are determined.

Corrosion and passivity U. F. Franck (*Korrosion* 12, 1960, 19–28) [In German].

Welded stainless steels for hot hydrogen sulphide service F. J. Bruns (*Corrosion*, 1961, **17**, May, 227t–231t) The author presents the results of a study of the corrosion rates of various grades of stainless steel exposed to a H_2–H_2S stream at 615°F in a commercial desulphurization unit. The effects of welding, heat-treatment, and composition are compared

Atmospheric corrosion of iron and steel B. Berglund (*TVF*, 1960, **31**, (8), 325–348) Recent investigations into the effect of atmospheric pollution at Sandviken give method employed with the results in seven tables. Field trials were also made. Impurities in the air, indoors, and outside, with temp. and humidity as factors are recorded. The question of combating corrosion indoors is discussed. Pollution in industrial surroundings is dealt with in two supplementary articles (the latter Kvarntorp–sulphur dioxide), and at atomic stations for production of fuel elements.

Steam and power generation: the problems of corrosion, blockage, and smut emission from combustion processes R. Ashman (*Steam Eng.*, 1961, **30**, May, 255–259).

Diagram of isothermal transformation for four Swedish standardized spring-steels G. Molinder (**Jernkont. Tek. Rad.*, 1958, **20**, (248), 155–164).

Low-temperature corrosion of boiler flues P. De Lachaux (*Chal. et Ind.*, 1960, **41**, March, 63–72).

Examination of a 1%Cr, 0·5%Mo steel superheater from Brimsdown power station after 20 years in service L. H. Toft and D. E. Wetherly (*Brit. Electric & Allied Ind. Res. Assoc.*, J/E/T 218, 51–66; International Discussion on Long-Time Performance of High Temperature Steels, Düsseldorf, June 1960, Paper 21).

Corrosion of the steel pipes of refineries by high-sulphur crude oil P. Csokán (*Korrosion* 12, 1960, 116–122) [In German].

High temperature corrosion by sulphur compounds in petroleum refining W. G. Richards (*Korrosion* 12, 1960, 122–126) [In German].

The problem of low temperature corrosion in oil-fired steam boilers G. Weber (*Mitt. Vereinigung Grosskesselbesitzer*, 1960, (65), April, 71–78) The factors which favour the formation of SO_3 in boiler systems are discussed, particularly the effect of lowering the temp. to the dewpoint in increasing attack, and measures to be taken to prevent low-temp. corrosion are indicated (35 refs).

The corrosion of mild steel in sulphur-containing gas streams T. K. Ross and A. J. Macnab (*Korrosion* 12, 1960, 111–116) [In German].

Steels for synthesis gas and hydrogen V. Cihal (*Korrosion* 12, 1960, 110–111) [In German] An outline account of the corrosive influences on high pressure apparatus for ammonia synthesis and other processes, due to the action of H_2 and N_2 on the C content of the steel. The properties of Ti–W steels were investigated, and a steel with 0·12%C max., 0·4–0·6%Ti, and 3–6%W is recommended.

Experience—especially in respect of vanadium corrosion—on a Benson boiler operating with blast furnace gas or fuel oil F. Sieverding (*Mitt. Vereinigung Grosskesselbesitzer*, 1960, (65), April, 78–87) A detailed report, presented at a meeting of the working group on oil firing of VGB, dealing with the operation of a 25–30 t/h Benson boiler fired either with oil or blast-furnace gas.

Cast iron in the construction of equipment for the chemical industry P. van der Forst (*Korrosion* 12, 1960, 105–109) [In German].

The influence of dust on the atmospheric corrosion of metals K. Barton (*Korrosion* 12, 1960, 86–89) [In German] Properties of a number of dusts were investigated, i.e. their absorption capacity for water vapour and SO_2 and the influence of soluble components, dust composition, and pH value. Tests included corrosion tests on unprotected steel.

The influence of photosynthesis on the corrosion of steel in seawater A. Hache, L. Barriety, and J. Debyser (*Korrosion* 12, 1960, 79–82) [In German].

Investigations on the pitting corrosion of high-alloy austenitic chromium–nickel steels and ferritic chromium steels in halogenide-containing aqueous solution G. Pier and W. Schwenk (*Korrosion* 12, 1960, 72–75) [In German] Applications of stainless steels in aqueous solutions containing halides are limited, due to the incidence of pitting corrosion; the mechanism of pitting corrosion is discussed, and the use of $K_3[Fe(CN)_6]$ as a rapid test is described.

The influence of flow on corrosion A. Upmalis (*B–W–K*, 1961, **13**, May, 219–221) The effect of fluid flow in some air heaters and water preheaters on their corrosion was studied. It is concluded that the main factors contributing to the corrosion are unequal flow, which leads to unequal deposit formation, to unbalanced heat transfer, and to temp. differences, causing the formation of local potentials. Some means of reducing the corrosion are suggested.—M.L.

Contact corrosion between metals and non-metallic materials in the atmosphere and in some electrolytes F. Podbrežnik (*Korrosion* 12, 1960, 68–72) [In German].

Corrosion of the tinplate container in the canning industry H. Cheftel (*Korrosion* 12, 1960, 38–44) Factors influencing corrosion of the interiors and exteriors of tinplate containers and their mechanism are discussed in detail, with reference to the literature (34 refs).

Chemical and electrochemical aspects of corrosion in the nuclear reactor G. H. Cartledge (*Korrosion* 12, 1960, 1–11) [In German] After reviewing the electrochemical corrosion processes on the phase boundaries: metal-protective film solution, the influences of radioactivity on these processes, and the reactions between the fission products and the reactor materials are examined. Results obtained in

the Oak Ridge Laboratories are described (44 refs).

Constancy of stainless steels against corrosion: corrosion tables G. Lindh (*Jernkontorets Tekn. Rad.*, 1946, **15,** (136), 327–375).

High temperature sulfur corrosion of intermediate range chromium steels R. E. Hannum (*Corrosion*, 1961, **17**, May, 201t–202t) 5%Cr–0·5%Mo tubes in a thermal oil desulphurization unit gave a service life of only 21 months. Laboratory tests with other steels indicate that 9%Cr tubes will give a service life of at least five years.—G. F.

Cathodic polarization of steel in salt water A. R. Erben (*Corrosion*, 1961, **17**, May, 222t–226t) A laboratory study has been made of the effect of several variables on the cathodic polarization of steel. The factors studied included temp. changes, the effect of two corrosive acid gases, the effect of varying amounts of an organic acid, and a comparison of fluids actually produced with synthetic fluids.

Rates of formation and structure of oxide films formed by a single crystal of iron J. B. Wagner jun., K.R. Lawless, and A.T. Gwathmey (*Trans. Met. Soc. AIME*, 1961, **221**, April, 257–261).

Scaling of steel containing 2·25%Cr and 1%Mo in steam and in air E. Gasior (*Brit. Electric & Allied Ind. Res. Assoc.*, J/E/T 218, 32–37; International Discussion on Long-Time Performance of High Temperature Steels, Düsseldorf, June 1960, Paper 18) The kinetics of the scaling process and the composition of scale on a steel (0·1%C, 0·35%Si, 0·44%Mn, 0·01%P, 0·21%S, 2·27%Cr, 0·87% Mo, and 0·03%Ni) during oxidation in steam and air over a temperature range 500–700° were studied. Examination was on the basis of weight increase using a thermobalance; oxidation in steam carried out over a 100–200 h period and up to 1 000 h in air. The scale was examined by metallographic, radiographic, and chemical methods and great variation in the rate was noted at 600° in both media; it is suggested that at this point a change in the scaling mechanism takes place.—C. V.

A micrographic and radiocrystallographic study of the coatings of oxide formed at the time of the corrosion of iron and steels by carbon dioxide P. Bastien and M. Colombie (*Compt. Rend.*, 1961, **252**, April 24, 2548) By a micrographic and radiocrystallographic study of the oxides formed on iron and steels in hot CO_2 and under pressure, there is evidence of the existence in the magnetite layer, of two possible fibrous textures characterized either by an axis of [100] or by an axis of [110], perpendicular to the surface of the metal. In the case of the pure iron, this second orientation seems concomitant with the presence of amorphous carbon precipitated on the external surface of the oxide.—S. H.-S.

Oxidation of iron–chromium alloys D. Lai and R. J. Borg (*PB* 149068, 1960, Feb., pp.36; *Metallurgy rept. No.*22; *AFOSR–TN*–60–387; *AD*–235785; from *US Res. Rep.*, 1961, **35**, Feb. 10, 200) The rates of oxidation of iron alloys containing 0·2 to 10%Cr have been measured from 750 to 1025°C. The accelerations in rate during an isothermal measurement do not occur at reproducible times or average thickness which suggests that scale fracture plays an important role. The ways in which Cr might contribute to a reduced rate of oxidation of iron are discussed.—C. F. C.

The burning of metals P. L. Harrison and A. D. Yoffe (*Proc. Roy. Soc.*, 1961, **261**, May 16, 357–370).

Special coupon shapes used in testing liner coatings O. W. Siebert (*Corrosion*, 1961, **17**, May, 16–18).

New investigations into the adsorption of hydrogen in the dissolution of iron L. Cavaliaro G. P. Bolognesi, and L. Felloni (*Korrosion* 12, 1960, 131–135) [In German] Experiments in the solution processes of iron in N HCl showed a correlation between the amount of H_2 taken up by the iron and its rate of dissolution. A dynamic saturation equilibrium was established in the interior of the iron, and an explanation of the action of inhibitors is put forward (10 refs).

An electron-microscopical study of the corrosion of electroplated nickel R. Weil (*Plating*, 1961, **48,** Feb., 163–167) The structural changes in electroplated nickel exposed to outdoor corrosion were determined by electron microscopy, when it was found that the structures of all deposits became similar after a one-year exposure, regardless of the as-plated appearance. The formation of pits which reached to the basis metal was accelerated by the addition of sulphur-containing agents to the plating bath. Pitting as observed by electron microscopy could not be related to pitting seen with the unaided eye, and electron microscopy appears to be a valuable tool in the study of corrosion of electrodeposits.—S. H.-S.

Application of electrochemical measurements to discover the causes of corrosion damage H. Schmecken (*Korrosion* 12, 1960, 236–239) [In German] Using current density curves, materials are investigated under operating conditions; several examples (steel) are described.

Use of polarization curves to investigate the local corrosion of stainless steels J. M. Defranoux (*Korrosion* 12, 1960 232–236) [In German] The suitability of anodic and cathodic polarization curves as a means of assessing the danger of pitting in large-dimension equipment for various corrosive agents is demonstrated.

Atmosphere corrosion of metals. III. Corrosion of metals in Calcutta B. Sanyal, B. K. Das Gupta, P. S. V. Krishnamurthy, and G. K. Singhania (*J. Sci. Indust. Res.*, 1961, **20D**, Jan., 27–30).

New methods of simulating corrosive plant conditions in the laboratory A. O. Fisher (*Corrosion*, 1961, **17,** May, 215t–221t).

Kinetic study of the current-emf characteristics of iron and steels I. Epelbois, M. Froment, and P. Morel (*Compt. Rend.*, 1961, **252,** May 3, 2702–2704) The form of the current-emf curves of an iron or steel electrode immersed in H_2SO_4 is influenced by the carbon content of the metal. It is shown that the iron presents a secondary passivity if the trace speed of polarization is suitably chosen.—S. H.-S.

On a surface energy mechanism for stress corrosion cracking E. G. Coleman, D. Weinstein, and W. Rostoker (*Acta Met.*, 1961, **9,** May, 491–496) The grain size dependence of stress-corrosion cracking stress in tensile loading has been studied in two stress-corrosion systems. The dependence has been analysed in terms of the Petch-Stroh equations for dislocation nucleated cracks to yield the effective surface energies. These have been shown to be of the proper magnitude for brittle fracture.

The electrochemical behaviour of stainless steels in sulphuric acid (I) H. J. Wiester, E. Brauns, and W. Schwenk (*Metalloberflache*, 1961, **15,** March, 73–76; April, 103–107).

Stress corrosion cracking of austenitic chromium–nickel stainless steels: Introductory summary F. L. LaQue (*ASTM, STP*, 1960, (264), 1–3).

Effect of acid volume and inhibitor quantity on corrosion of steel oil field tubing in hydrochloric acid W. E. Billings and D. Morris (*Corrosion*, 1961, **17,** May, 208t–214t).

The relationship between the tempering and corrosion behaviour of hardenable stainless chromium steels A. Bäumel and C. Carius (*Arch. Eisenh.*, 1961, **32,** April, 237–249) The change in Vickers hardness and corrosion behaviour of three steels (0·4%C and 14%Cr; 0·5%C, 15%Cr and 0·5%Mo; 1·1%C, 18%Cr, and 1%Mo) after tempering. The changes of the corrosion behaviour, above 475°C, are explained on the basis of the separation of high Cr carbides which remove Cr from their immediate vicinity and decrease the corrosion resistance.—M. L.

Stress corrosion cracking of austenitic chromium–nickel stainless steels: General information A. W. Dana jun. and W. Z. Friend (*ASTM STP*, 1960, (264), 4).

Stress corrosion cracking of austenitic chromium–nickel stainless steels: Equipment, mode and location of fractures and associated conditions E. E. Denhard (*ASTM STP*, 1960, (264), 5–6).

Corrosion testing in the oxygen chamber E. Erdös (*Metalloberflache*, 1961, **15,** Jan., 21–23) A special chamber in which the oxygen is unaccompanied by N_2 makes possible accelerated corrosion tests which closely resemble the naturally occurring processes at an accelerated rate, especially when other corrosive gases are added. This is due mainly to the increased solubility of O_2 and the other corrosive gases in the water on the metal surface. The application of this corrosion testing method gave results which compared advantageously with customary methods.—M. L.

The influence of atmospheric corrosion on the fatigue limit of iron–0·5% carbon N. J. Wadsworth (*Phil. Mag.*, 1961, **6,** March, 397–401) Iron–0·5%C was fatigued in air and in vacuum. It was found that the knees in the S–N curves occurred at about the same number of cycles, but at a higher stress in air than in vacuum. Slip occurred in the same manner above and below the fatigue limit, and cracks formed in the slip bands, although the cracks did not propagate below the fatigue limit.

Corrosion and Metal Finishing Exhibition, 1960 Sir A. Fleck (*Corros. Techn.*, 1960, **7,** Dec., 387–390) The opening address.

Tests on the corrosion of 13%Cr steels W. Peter and E. G. Gondolf (*Arch. Eisenh.*, 1961, **32,** May, 337–343) [In German] The weight loss of steels of about 0·08 to 0·45%C and 12·3 to 15·2%Cr is calculated in corrosion tests up to about 250 h in boiling acetic, citric, oxalic, and nitric acids. Aspects dealt with include the annealing temp. after hardening and the δ-ferrite content on corrosion resistance.

Influence of melting atmospheres on corrosion resistance of 18–8 stainless steels R. Tanaka and R. Ito (*Tetsu-to-Hagane*, 1960, **46,** Sept., 1407–1409) The results of corrosion tests in boiling 1%HCl solutions and of 3 h intercrystalline corrosion tests in a 69%HNO_3 boiling solution containing CrO_3 are given.

An increase in the resistance of strip made from steel 1Kh18N9T to intercrystalline corrosion, with a titanium content at the lower limit N. P. Zhetvin (*Stal'*, 1961, (6), 557) A note from 'Serp i Molot'. Heat-treatment (quenching from a lower temp.) is recommended.

Corrosion of austenitic stainless steel in CO_2 A. Draycott and R. Smith (*Met. Ind.*, 1961, **98,** March 10, 187) Stainless steel is used as a cladding material for nuclear fuel elements in reactors where CO_2 is a coolant and the working temperature ranges between 550 and 750°C. It is concluded that the oxidation resistance of 18–8–1 Ti stainless steel is due to selective oxidation of the Cr giving a protective film of Cr_2O_3.—A. H. M.

The influence of temperature of corrosive solution on the corrosion fatigue strength K. Endo (*J. Japan Soc. Test. Mat.*, 1960, **9,** Dec., 749–752; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 482).

Effect of untempered martensite on susceptibility of AISI 410 steel to stress-corrosion cracking H. Suss (*USAEC Report KAPL*–2000–9 (*TID*–4500, 15th Edn.), 1960, March, B.35–B.38) Studies at the Bettis Atomic Power Laboratory and at KAPL of AISI 410 steel austenitized at 1850–1850°F, air-cooled to room temp., and tempered at 1125°F (minimum) for 4 h are reported, and resultant phenomena are presented and discussed, the extent of stress-corrosion cracking being a function of the amount of untempered martensite.—S. H.-S.

Susceptibility of AISI 410 to stress-corrosion cracking in high temperature, high purity water H. Suss (*Nat. Assoc. Corros. Engrs.*, 1960, Aug., 17–33) (1) AISI 410 steel tempered at 650°F to hardness of Rockwell C36–42 exposed for 6 months with applied stresses up to 80 000 did not indicate susceptibility to stress-corrosion cracking in hydrogen ammoniated (pH 8·5–9·5) or hydrogen-lithium hydroxide waters (pH 11) at 300°F. (2) Chromium plating at same specification gave anomalous results. (3) Oxygen in either of above water systems caused accelerated stress corrosion failures, especially for chromium-plated samples, with applied stresses as low as 60 000 psi and possibly as low as 40 000 psi. (4) Nickel plate, 0·003in minimum, may offer protection against stress-corrosion failure in 300°F high purity waters, but more data are required. (5) Shot peening will materially reduce (if not eliminate stress-corrosion susceptibility of AISI 410 tempered to a hardness of RC 36–42.

(6) The presence of a grain boundary constituent and 'delta ferrite' could be factors contributing to initiation of stress-corrosion cracking, crack propagation, and affecting time-to-failure for AISI 410 hardened to RC 36–42. (7) AISI 410 tempered at 110°F and higher is not susceptible to stress-corrosion cracking. Theories for this immunity are outlined.—S.H.-S.

Corrosion study of metals for supercritical pressure power plants R. C. Ulmer (*Nat.Assoc. Corros. Engrs.*, 1960, Aug., 68–81).

Use of neutron activated specimens for the study of corrosion product release rates G. P. Simon (*Nat. Assoc. Corros. Engrs.*, 1960, Aug., 60–67).

Effect of high-speed airflows on the failure of heated iron V. I. Prosvirin and L. Ya. Nesgovorov (*Izvest. AN Otdel. Tekhn. Met. i Toplivo*, 1961, (2), 122–131) A method has been evolved for studying the effect of rate of airflow on the rate of corrosion–erosion failure of heated metals which produces reasonable agreement in repeated experiments and makes possible an investigation of the effect of many factors on the failure of metals. These are described (19 refs).—A.I.P.

Corrosion of cast iron pots used for fusing caustic soda S. Rao Addanki, A. K. Lahiri, and T. Banerjee (*NML Techn. J.*, 1960, **2**, Nov., 6–9).

Rust preventative effects of alkylamides of dibasic acids S. Shimada (*J. Japan Soc. Lubr. Engrs.*, 1960, **5**, Nov., 355–358; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 491) [No abstract].—C.F.C.

T.O.P.I.C. Anti-corrosives (*Corros. et Anticorros.*, 1960, **8**, Dec., 475) [In French] The phosphatization process produces a surface chemical transformation of ferrous metals to which paints, lacquers, and varnishes adhere better. Ten proprietary anticorrosive treatments of English origin for various purposes are briefly described.

Traffic cop for corrosion [Zirconium] Carborundum Co. (*Advanced Mat. Techn.*, 1960, **3**, Jan., 2–3).

A decade of progress. Industry's contribution to corrosion prevention (Part 3) Plus-gas developments (*Corros. Prev.*, 1961, **8**, June, 39–40).

On the session 'Corrosion and corrosion protection on ships and in harbour' held on 22–25 June 1960 in Hamburg (*Metall-Reinigung+Vorbehandlung*, 1960, **9**, Oct., 179–183).

The cathodic protection of buried steel pipelines L. A. Woodworth and F. P. A. Robinson (*South African Mech. Eng.*, 1961, **10**, April, 231–257).

Protection of gas holders by use of coatings H. Prim (*Corros. et Anticorros.*, 1960, **8**, Dec., 462–471) [In French].

Bimetallic heat exchangers tubes solve dual corrosion problem W. G. Ashbaugh and S. E. Doughty (*Met. Prog.*, 1960, **78**, Dec., 115–117, 128, 130, 132) Use of bimetallic tubes made by drawing Cu or brass over welded stainless tube, prevented stress-corrosion cracking and pitting on the outside from brackish cooling water. The stainless steel interior withstood the corrosive action of the chemicals being processed.

Corrosion and its prevention for oil tankers M. Seo and S. Takeshima (*J. Soc. Naval Arch. Japan*, 1960, Dec., 413–417) from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 490) Corrosion tests of tank compartments in their different service conditions are reported. The corrosion rate of test-pieces installed in tanks which were alternately filled with crude oil and kept empty (not filled with sea water) was 0·072∼0·23 mm/yr; this was more severe than was expected. When tanks were alternately filled with crude oil and dirty ballast sea water, the corrosion rate was slightly higher than the above values. The tanks filled with clean ballast sea water were corroded as much as 0·24∼0·36 mm/yr.—C.F.C.

An example of long-term protection against corrosion by zinc metallizing J. Cauchetier (*Corros. et Anticorros.*, 1960, **8**, Dec., 472–474) [In French].

Corrosion control of copper and steel by vacuum deaeration [of recirculating water] M. E. Tester (*US Dept. Comm. Tech. Serv.* GAT–296, 1960, May 18, 3–14).

Performance of zinc anodes for protecting ship hulls M. Seo and H. Kato (*J. Soc. Naval Arch. Japan*, 1960, Dec., 407–412; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7**, Feb., 491).

Stress corrosion cracking of austenitic chromium–nickel stainless steels: Classification of materials and stress conditions F. K. Bloom (*ASTM STP*, 1960, (264), 7–8).

Stress corrosion cracking of austenitic chromium–nickel stainless steels: Classification of corrosion conditions W. B. Brooks and M. E. Holmberg (*ASTM STP*, 1960, (264), 9–11).

Stress corrosion cracking of austenitic chromium–nickel stainless steels: Steps taken to overcome cracking F. K. Bloom (*ASTM STP*, 1960, (264), 12–14).

Stress corrosion cracking of austenitic chromium–nickel stainless steels: A survey of current research activities A. W. Dana jun. and W. Z. Friend (*ASTM STP*, 1960, (264), 17–21).

Stress corrosion cracking of austenitic chromium–nickel stainless steels: The mechanism of cracking J. J. Harwood (*ASTM STP*, 1960, (264), 22–24, 63–67).

Stress corrosion cracking of austenitic chromium–nickel stainless steels: Bibliography and abstracts on stress-corrosion cracking of stainless steel 1935–1957 R. M. Fuller, G. T. Paul, and A. J. Marron (*ASTM STP*, 1960, (264), 69–72) (245 refs).—C.V.

A comparison between the results of exposure tests in industrial atmospheres and accelerated corrosion tests in sulphur dioxide atmospheres A. Kutzelnigg (*Korrosion* 12, 1960, 214–219) [In German] The Trestor apparatus is described, data on the condensation of water vapour as a function of time are given, and the results of accelerated tests in the apparatus on coated steel and cast iron are given and assessed (20 refs).

Measurement of intercrystalline corrosion by means of the 'resonance frequency method' K. Smrček (*Korrosion* 12, 1960, 239–242) [In German] The construction and operation of an apparatus is described, in which the resonance frequency, which changes according to the degree of corrosive attack is indicated by the change in tone of the sample, or by means of silicon powder which focuses at the nodal point.

On the diagnosis of the causes of corrosion from corrosion products G. Schikorr (*Korrosion* 12, 1960, 219–222) [In German].

Corrosion resistance and corrosion fatigue in gas-nitrided titanium steels M. Tömöry-Rónay (*Metalloberflache*, 1960, **14**, Dec., 360–365) The mechanism of corrosion fatigue is discussed. Mechanical and metallographic examinations are described, comparing the corrosion fatigue resistance of mild, nitrided titanium, and Cr–Al–Mo steels under various conditions.—R.P.

Investigations of the tendency of passivated chromium–nickel steels to intercrystalline corrosion, by means of a potentiostat M. Pražák (*Korrosion* 12, 1960, 242–244) [In German] It was found that the passivation potential of the grain boundaries of the austenitic grains of steels with 5–8%Cr is higher than that of the grains themselves, according to the degree of Cr impoverishment, and it is shown that the etching of such specimens at $-0{\cdot}1$ V *v.* the calomel electrode is a satisfactory test for determining the tendency towards intercrystalline corrosion.

Electrochemical behaviour of bimetallic electrodes and the use of the overvoltage curves of these electrodes in corrosion research G. Bianchi and G. Caprioglio (*Korrosion* 12, 1960, 48–51) [In German].

Investigations on the corrosion of pressure pipelines and the appropriate protective measures C. Tschappat (*Korrosion* 12, 1960, 28–38) [In German].

On the importance of the physical properties of the soil to the reaction mechanism of iron in soil T. Marković (*Korrosion* 12, 1960, 12–18) [In German] The influence of various factors on the corrosion of iron in soil is reviewed, the most important being the adhesive power of soil to water. Model experiments with glass balls are used to explain the possible types of contact corrosion, the results are discussed, and it is shown from work carried out by the American Bureau of Standards on iron corrosion in 47 soils in the USA that corrosion rate is a function of the average annual rainfall (11 refs).

Resistance of gas turbine metal to vanadium pentoxide corrosion when sulphur-containing fuel oils are used E. G. Ginzburg, R. A. Lipshtein, and S. E. Khaikina (*Issledovaniya po zharoprochnym splavam*, Moscow, 1960, **6**, 140–145).

Inhibition of the hydrogen corrosion of iron by phenylthiourea H. Kaesche (*Korrosion* 12, 1960, 139–141) [In German].

New investigations in the field of vapour phase inhibitors L. Cavallaro and G. Mantovani (*Korrosion* 12, 1960, 145–148) [In German] The effects of a number of vapour phase inhibitors on the stability in storage of grey cast iron in air of 100% relative humidity were investigated. Paper wrappings impregnated with v.p.i. can be used successfully.

Surface reconditioning of the Key West water pipeline K. A. Gruber (*Corrosion*, 1961, **17**, May, 20).

Protection against anodic corrosion (*Tekn. Tidsk.*, 1961, **91**, March 3, 195–200) The motive power of corrosive reaction may either be reduced or it may be provided that corrosion products impede reaction by forming a protective layer. In the former case the immunity, in the latter the passivity of the material is utilized. The method is described and laboratory results tabulated. Under industrial application are explained risks, apparatus, and use in sulphonating plants.

Corrosion protection of steel structures immersed in water, using flame-sprayed zinc coatings Z. Kowalski (*Korrosion* 12, 1960, 180–186) [In German].

Prevention of corrosion and deposits H. E. Crossley ('*Major Developments in Liquid Fuel Firing* 1948–1959', *Inst. Fuel.*, 1959, **D–8**, 12).

Corrosion protective methods in light-oil tankers R. H. Maass and R. D. Merrick (*Korrosion* 12, 1960, 226–232) [In German].

Responsibilities of high performance maintenance coating manufacturer C. G. Munger (*Corrosion*, 1961, **17**, May, 26).

Effect of some application variables on maintenance coating performance J. R. Allen, F. W. Thompson, and M. L. Monack (*Corrosion*, 1961, **17**, May, 22–24) The authors report an attempt to develop a method for evaluating ease of application of a protective coating. They have investigated the thickness and continuity of coating films and considered such variables as distance from spray gun to surface, air caps, and atomizing air pressure. Field performance correlates well with data derived from laboratory tests.—G.F.

ANALYSIS

The preparation of chemical standards in the Institute of Iron Metallurgy J. Inglot (*Chemia Anal.*, 1961, **6**, (1), 111–119) After considering the use of standards in routine analysis the author deals with the technique of standard preparation and the work done in the institute to date. In conclusion the author deals with the plans for the production of steel standards in the Chemical Standards Laboratory.

Account of the activities of the International Committee for the Investigation and Rationalization of Methods of Gas Analysis in Steels and Irons P. Tyou and M. Lacomble (*Rev. Univ. Min.*, 1960, **16**, March, 163–167) The origin of the Committee is described, Belgian work on the determination of H_2 in liquid steel reviewed, and work in the determination of N_2 is outlined.

Progress in steelmaking—analyses teletyped to melting shops and mills W. P. Horscroft (*Steel*, 1961, **148**, May 1, 64, 66).

Microdetermination of carbon in metals J. W. Frazer and R. T. Holzmann (*UCRL*–6020, June, 1960, pp.7; from *Nucl. Sci. Abs.*, 1960, **14**, Dec. 31, 3284) C in metals can best be determined by high-temp. oxidation of the sample and subsequent measurement of the evolved CO_2. An apparatus and procedure are described which constitute a modification of a capillary-trap determination method. The modification resulted in a simplified portable apparatus (20in wide, 15in deep, and 42in high) The method is applicable to metals with high S and N contents.—C.F.C.

Notes on the determination of sulphur in

steel R. Boulin and E. Jaudon (*Chim. Anal.*, 1961, **43,** May, 221–224) [In French].

Determination of nitrogen in steel T. Mori, K. Fujita, and I. T. Kim (*Suiyokwai-Shi*, 1959, **14,** Dec., 35–38) In the determination of small amounts of N_2 in steel by steam distillation in the micro-Kjeldahl apparatus, a colorimetric method using chloramine-T and a mixture of pyrazolone and bispyrazolone in pyridine was examined, and this method was compared with Nessler's reagent. Results obtained are as followed: The main advantages of the former are of high sensitivity and precision. The higher sensitivity and precision can be obtained by using purified reagents. The procedure, however is a little complicated. On the other hand, Nessler's reagent is simple and inexpensive. This is convenient in the case of analysing many samples at the same time, provided that the conditions for colour development are kept constant.—R.S.F.C.

Study on the sampling method for determination of hydrogen content in molten pig iron S. Maekawa, Y. Nakagawa, M. Soga, and M. Sudo (*Imono*, 1960, **32,** Sept., 658–663) A vacuum method is described.

Fabrication and working of the vacuum fusion apparatus for the determination of gases in metals and alloys N. G. Banerjee (*NML Techn. J.*, 1960, **2,** Nov., 10–14) The simple construction of the apparatus and accuracy of the results are discussed and it is advantageous to have the gas analysis section isolated from the main apparatus so as to simplify operation and maintenance. Simultaneous determination of O, H, and N-content of a large number of metals (steel, ferrous-alloys, Cu, Ni, etc.) gave satisfactory results and the oxides in Cu were determined by using the iron liquid bath.Reduction of Ni-oxide is more rapid and efficient if this bath is employed despite the fact that Ni is a carbide former.—C.V.

New method for the determination of metallic bivalent and tervalent iron in iron-containing materials N. Stoll and A. Wagner (*Rev. Univ. Min.*, 1960, **16,** Oct., 436–443) The sample is dissolved in acid under an inert atmosphere, the H_2 liberated is measured chromatographically to give metallic Fe, the sum of metallic Fe and Fe^{2+} is obtained by a manganimetric titration, and Fe^{2+} is given by difference, Fe^{3+} is found by a manganimetric titration of $Fe+Fe^{2+}+Fe^{3+}$, giving Fe^{3+} by difference (25 refs).

Determination of vanadium in special steel H. Shiokawa and S. Hanaoka (*Hitachi Hyoron*, 1960, **42.** Nov.; 1221–1223; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 595) [No abstract].—C.F.C.

Thiomalic acid as a reagent for the photometric determination of molybdenum A. I. Busev and Chang Fan (*Zhur. Anal. Khim.*, 1961, **16,** (2), 171–179).

Gravimetric determination of zirconium after its precipitation by cyclohexanol-1-carboxylic acid I. P. Alimarin and Shen Hanhsi (*Zhur. Anal. Khim.*, 1961, **16,** (2), 162–165).

Photometric determination of zirconium with xylenol orange V. F. Luk'yanov and E. M. Knyazeva (*Zhur. Anal. Khim.*, 1961, **16,** (2), 248–249).

Quantitative chemical single determination of non-ferrous metals as alloying partners in iron and steel. Report No.1 A. Klinkmann (*Metall.*, 1960, **14,** Dec., 1190–1194) Methods are described for the volumetric determination of Mn in plain C and alloy steels the photometric determination of Cu, volumetric determination of Si and Cr, Cr and V, and the potentiometric determination of Cr and V.

Study of the colorimetric determination of tin in iron and steel. (1) On the interference of vanadium in the JIS-Cacotheline method and its elimination S. Morita and N. Inoyama (*Suiyokwai-Shi*, 1959, **14,** Dec., 47–52).

Separation of traces of gold from large amounts of copper and iron prior to its colorimetric estimation by means of calomel W. Dziedzianowicz (*Chemja Anal.*, 1960, **5,** (5), 827–829).

Spectrographic determination of oxygen in steel M. B. Rosen (*20th Cong. GAMS*, 3–6 June, 1957, 237–243) The sample is heated in a special crucible to 2500°C in A, and the relative intensity of CO bands/A determined.

Investigation of mineral chromites by thermogravimetric analysis and infra-red spectrography C. Duval (*20th Cong. GAMS*, 1957, 3–6 June, 101–104) The composition of a number of chromites was examined by these techniques.

Use of X-ray fluorescence in metallurgy G. Pomey (*Mec. Electr.*, 1961, **45,** April, 50–53) [In French] A previous article dealt with metallurgical analysis using fluorescence and X-rays. This article indicates the progress made in X-ray fluorescent analysis of ores and steels and in thickness control on an industrial scale as well as in the research laboratory.The flexibility and simplicity of the process accounts for its wide application.

Determination of small amounts of niobium in ores containing titanium, tungsten, molybdenum, and chromium V. M. Dorosh (*Zhur. Anal. Khim.*, 1961, **16,** (2), 250–252).

Determination of niobium and tantalum in ores M. J.-M. Lopez de Azcona (*20th Cong. GAMS*, 1957, 3–6 June, 205) The ratio Nb/Ta is determined spectrographically using a low voltage arc, and the line pairs Nb 3116.365 Å, Ta 3115.859 Å. To the sample is added a mixture of C, Zn, and $KClO_3$.

A method of determining the phosphorus in wolfram-ore photometrically C. Winterstein (*Z. Erz. Met.*, 1960, **13,** Nov., 546–549) [In German] This process is based on the fact that a weak HNO_3 solution of NH_4 vanadate and NH_4 molybdate turns yellow or orange-yellow when phosphoric acid is added, and the degree of coloration is proportional to the amount of H_3PO_4 added.

A rapid flame-photometric method for the determination of Na_2O and K_2O in various refractories K. Konopicky and W. Schmidt (**Ber. Deutschen Keram. Ges. eV.*, August 1960, 368–371).

On the rapid determination of phosphorus in steelworks (*Fonderia*, 1961, **10,** (4), 173–174) [In Italian] Normally the determination of phosphorus by titration in steelworks laboratories takes 30 min and longer for low-phosphorus OH and basic Bessemer steel. A new instrument called Nick takes only 7–8 min. The electric impulse given by electrolysis accelerates the particle growth of ammonium phosphomolybdate and produces precipitation within 15 sec.

The colorimetric micro-determination of nickel as triphenylmethylarsonium bis-dithiooxalatonickelate (II) A. J. Cameron and N. A. Gibson (*Anal. Chim. Acta*, 1961, **24,** April, 360–364).

On the complexometric titration of molybdenum. 2nd Communication E. Lassner and R. Scharf (*Zeitschrift fur Analytische Chemie*, 1959, **168,** (6), 429–433) The authors show that their previously published method for the determination of Mo with EDTA can be applied on the microscale, using 0·005 M solutions. Bi, Cd, Zn, Co, Ni, Cu, Hg, V, Cr, and Pb interfere by complex-formation with EDTA, iron interferes by reducing the copper solution used in back-titration. Interference by Ti, Nb, Ta, W, Th, Al, Ce, La, and V can be overcome by adding fluoride and tartaric acid.—R.P.

Analytical chemistry of arsenic, antimony, and copper in steels and iron ore (*Stahl Eisen*, 1961, **81,** Feb. 16, 253) The various methods including polarographic and photometric for the trace analysis of the elements As, Sb, and Cu in steels and iron ore are reviewed.—T.G.

A rapid determination of the aluminium content of steel without separating the iron H. H. Doleschel (*Stahl Eisen*, 1961, **81,** March 30, 448–449) The working instructions for the estimation of Al in steel are given. The estimation is photometric with Eriochrome-cyanine after reduction of the iron with ascorbic acid. The estimation of the acid-soluble Al takes 15 min, total Al 90 min.

Separation and determination of rare earth elements in iron and steel. I. II. Determination of cerium and lanthanum in iron and steel S. Takeyama, E. Sudo, and H. Goto (*Sci. Rep. Res. Inst., Tohoku Univ.*, 1960, **12,** Oct., 407–415; 416–422) [In English].

Formaldoxime as an analytical reagent. III. Behaviour of the reagent in solution. The colorimetric determination of iron Z. Marczenko and K. Masiura (*Chemia Anal.*, 1961, **6,** (1), 37–49).

Recovery of chloroform after use in solvent extraction analyses H. Green (*BCIRA J.*, 1961, **9,** May, 382–384).

Spark testing of steel: a simple and rapid method of identification A. G. Gardner (*Iron Steel*, 1961, **34,** April, 149–153) The equipment required is simple, an abrasive wheel (>4500 ft/min peripheral speed), spark cabinet, and goggles. Small particles of metal are thrown off, are oxidized and heated to incandescence; colour, shape, and size depend on type and quantity of the chemical elements present in the steel; other theoretical aspects are dealt with. C, Mn, Ni, Cr, Mo, V, W, and Si can be detected and the special characteristics are described; V is the only constituent that may present difficulties mostly on account of the small concn. present. Three main groups found are (a) plain carbon and low alloy steels, (b) the stainless group, and (c) the tool and die steel group; the spark characteristics of each group are discussed.—C.V.

A new method for rapid determination by spectrographic analysis Okada, Tomio, Nakai, Shigeo, and Kohzuma (*Trans. Bunseki Kagaku* (*Japan*), 1956, **5,** (4), 203–205; from *US Techn. Trans.*, 1960, **4,** Sept. 28, 310) While investigating the theoretical aspect of the time consumed for an analysis it was discovered that quantitative analysis can be relatively simply and rapidly performed by using two stepped filters. The results obtained by using this method in the quantitative analysis of manganese in steel and the analysis of barium in oil show that the mean relative error from the analysis of manganese content in steel was ±3·90% and that of barium in oil was ±8·76.

Determination of sulphate in chromium plating solutions C. M. Hanna (*PB* 152393, 1960, Feb., pp.8; *SA–TR*16–1115; from *US Res. Rep.*, 1961, **35,** Feb. 10, 144).

Report on Standard Samples for Spectrochemical analysis R. E. Michaelis (*ASTM STP*, 1960, (58–D), pp.119).

Spectrographic determination of ferroalloys. I. Spectrographic determination of microamounts of arsenic and antimony in ferromanganese Y. Tokoyama (*Sci. Rep. Res. Inst. Tohoku Univ.*, 1960, **12,** Aug., 346–352) [In English] A quartz spectrograph of medium type is used. Ag is introduced as internal standard, and a mixture of powdered sample with graphite is excited by dc intermittent arc. As and Sb are found with respective variation coeff. of 5–11 and ~6%.—K.E.J.

Spectrographic determination of ferroalloys. II. Determination of microamounts of lead, copper, and zinc in ferromanganese. III. Determination of impurities in ferrochrome T. Yokoyama (*Sci. Rep. Res. Inst. Tohoku Univ.*, 1960, **12,** Oct., 423–429; 430–436) [In English] II. A medium-type quartz spectrograph is used, and line pairs are chosen, using Mn as internal standard. Pb, Cu, and Zn are determined with respective coeff. of variation of 4–7, 6–7, and 14–16%. III. Similarly, Cr is used as internal standard for determining Si, Mn, Cu, and Ti.

Spectrographic analysis of slags—the present position A. Argyle (*BCIRA J.*, **9,** May 364–376).

Operational rapid determination of SiO_2 and Na_2O for calculating the modulus of sodium waterglass for the CO_2 process H. Thomann, O. Gerstmann, and B. Beyer (*Giessereitechn.*, 1960, **6,** Aug., 244–245).

The carbon content of low carbon magnesite M. L. Verheijke (*Philips Res. Rep.*, 1960, **15,** Dec., 437–444).

INDUSTRIAL APPLICATIONS AND USES

The use of wire for screens E. O. Riedel (*Wire*, 1960, Oct., 194–200).

Triplex steels for plough mould boards (*Aciers Fins. Spéc.*, 1960, Dec., 44–57).

Quenched and tempered steels in ship structure T. J. Dawson (*Weld. J.*, 1961, **40,** April, 175s–181s) A comparison is drawn between catastrophic failures of ships during World War II and the advantages presented by quenched and tempered high-yield materials available today for shipbuilding construction, and some problems arising from their availability and use are surveyed.—S.H.-S.

Research on rudder stock of cast and forged

steel. (1) M. Okabayashi, M. Kawai, and T. Tamaki (*Hitachi Zosen Giho*, 1960, **21,** Nov., 231–237; from *Japan Sci. Rev. Mech. Elect. Engr.*, 1961, **7,** Feb., 546) [No abstract].

The steel tube as a structural element W. Jamn (**Techn. Mitt.*, 1959, **52,** March, 89–94).

Study on precipitation hardening stainless steel for spring Y. Mishima, T. Fujita, Y. Sakaba, K. Inoue, and I. Matsuo (*Ann. Rep. Eng. Res. Inst. Univ. Tokyo*, 1960, **19,** Sept., 92–95) 15 Cr–7Ni steel with Mo and Al is inferior to 17–7 pH for springs. Steels with Ti of W were too hard even after tempering.

Calculation of helicoidal springs, by slide rule J. E. Plainevaux (*Mec. Electr.*, 1961, **45,** April, 60) [In French].

Properties of heat exchanger tubes made of Kh8 steel V. G. D'Yakov (*Stal'*, 1961, (6), 538–540) The method of tube production is outlined and the composition and properties of Kh8 steel are given. Its substitution for the more expensive and less resistant Kh5M steel is recommended.

Prestressed concrete steel bars T. Tsujimoto (*Kobe Seiko*, 1960, **10,** Oct., 286–299; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 593) [No abstract].—C.F.C.

Design information on pH15 –7 Mo stainless steel for aircraft and missiles R. J. Favor, O. L. Deel, and W. P. Achbach (*PB* 151093, 1060, Aug., pp.43; from *US Res. Rep.*, 1960, **34,** Dec. 16, 758).

Carbon steel for the Handford new production reactor W. D. Gilbert (*HW*–58299 Rev., 1958, Nov., pp.17; from *US Res. Rep.*, 1960, **34,** Dec. 16, 807) [No abstract].—C.F.C.

Use of 18/8 stainless steel for curtain walling in Laxon at Nancy P. Boyaux and G. Dromille (*Rev. Nickel*, 1960, **26,** Nov.–Dec., 157–161) [In French].

Steels for containers for liquified gases W. S. Mounce, J. W. Crossett, and T. N. Armstrong (*Rev. Nickel*, 1960, July–Aug., 87–100) Types of steel available, specifications, types of gases concerned, the problem of brittle fracture, and other mechanical properties of importance are discussed, including weldability. An appendix contains the composition and properties of a number of suitable steels.

Competition for windows made of 18/8 stainless steel (*Rev. Nickel*, 1960, **26,** May–June, 77–78) [In French].

Some post-war developments in naval construction A. J. Sims (*NE Coast Inst. Eng. Shipbuilders*, Preprint, 1961, 185–224).

Transversal rib reinforced steel. Stilln, possibilities of application and present state of test procedures W. Lierow (*Technik*, 1961, **16,** April, 321–323).

Stainless foils corrosion Epoxylite Corp. (*Steel*, 1961, **148,** April 24, 130–131) A process using stainless foil as a mould for epoxy resin, thus eliminating the need for permanent moulds for curing the plastic is described.

Design and manufacture of reactor vessels D. K. Davies (*Met. Prog.*, 1961, **79,** March, 101–104, 148, 153A, 153C, 154).

18/8 Stainless steel aids the security of Boeing 707 windows (*Rev. Nickel*, 1960, **26,** Nov.–Dec., 166–167) [In French].

Light and tough bolts made of Ti–Fe alloy. (1) Trial manufacture of the wire K. Hirayama and T. Takei (*Rep. His. Phys. Chem. Res.*, 1960, **36,** (3), 311–315) [No summary].

Metals and fabrication methods for the B–70 W. A. Reinsch (*Met. Prog.*, 1961, **79,** March, 70–77).

Metallurgy in nuclear power technology J. C. Wright (*Met. Treatment*, 1961, **187,** April, 153–156, 164) This is the seventh article in this series and the author deals with the effect of irradiation on non-fissile metals. The effect on the stress-strain relationship is discussed together with other mechanical properties such as creep characteristics and impact resistance. Transmutation effects are briefly discussed.

HISTORICAL

The manufacture of iron sword scabbards at the time of La Tène A. France-Lanord (*Rev. d'Hist. Siderurgie*, 1960, **1,** 7–12) [In French].

The oldest processes for the production of technical iron by direct reduction of ores with charcoal in bloomery hearths and bloomery furnaces and the production of steel directly from the iron ore B. Neumann (*Freiberger Forschungshefts*, (1954), pp.107) An historical study, including analytical results of ancient iron items (64 refs).—M.L.

Iron making in Champagne in the Middle Ages G. Gille (*Rev. d'Hist. Siderurgie*, 1960, **1,** 13–20) [In French].

Iron making by a Cistercian Abbey—Clairvaux R. Fossier (*Rev. d'Hist. Siderurgie*, 1961, **2,** 7–13) [In French].

The Sheffield thwitel: the historical development of the iron industry in the north of England before A.D. 1400 R. A. Mott (*Edgar Allen News*, 1961, **40,** April, 87–89) The gradual transition (owing to constant Scottish raiding pressure) of forges from Durham and Cleveland through the southern portion of the North Riding into the West Riding between 1150 and 1500, and the subsequent trend of ironmaking into Hallamshire and the south parts of Yorkshire to gain further safety from the Scottish raids, are reviewed. Historical data on the iron industry and its location, operations and markets for its products (largely weapons and accoutrements in Hundred Years War with France and the Wars of the Roses) are presented in some détail and a comparison is drawn between the Yorkshire Sheffield and the Sussex Wealden industries, with a preponderance of probabilities in favour of the former in the matter of Chaucer's 'Sheffield twitel'. The paper concludes with a biographical sketch of three generations of the Chaucer family in the service of the House of Lancaster branch of the Plantagenets, Geoffrey, the poet, of the second generation, being in 1367 in the service of Edward III. The paper concludes with the observation that in Chaucer's day, London was the great centre of cutlery manufacture, with York occupying second place and that the Sheffield industry could not compare in magnitude with York's until two centuries after Chaucer's death, though started in the Hallamshire area long before Chaucer was born.—S.H.-S.

The attempts at improving steelmaking in Dauphiné at the end of the 18th Century P. Leon (*Rev. d'Hist. Siderurgie*, 1960, **1,** 21–42) [In French].

The technical problems of the French steel industry in the 19th Century B. Gille (*Rev. d'Hist. Siderurgie*, 1961, **2,** 15–47) [In French].

The disappearance of rural iron making J. B. Silly (*Rev. d'Hist. Siderurgie*, 1961, **2,** 47–61) [In French].

Some of the history of development of the Bessemer process at Edsken Blast Furnace 1857–1858 G. T. Lindroth (*Blad för Bergshandteringens Vänner*, 1960, **34,** (4), 143–222).

Protection of cleaned iron objects K. J. Barton (*Nature*, 1961, **190,** April 1, 15; from the *Museums Journal*, Feb.) Phosphate coating is recommended but as the colour is poor and patchy it is suggested that the coating be dyed black with 'Hematine'. Vapour-phase inhibitors were also tested. Shell 220 and 260 are effective for steel, iron, and tinplate and nonferrous metals other than Pb and Cu.

Francois Bonhomme—the Blacksmith B. Gerard (*Rev. d'Hist. Siderurgie*, 1960, **1,** 43–51) [In French].

Portrait: Ernesto Manuelli (*Met. Bull.*, 1961, **49,** Feb., 28, i).

Notes on the iron trade in Western Europe from the 13th to the 18th centuries. I R.-H. Bautier (*Rev. Histoire Sidér.*, 1960, **1,** 4th quarter, 7–35).

Description of an [Italian] iron works in the 15th Century A. A. Filarètes (*Rev. Histoire Sidér.*, 1960, **1,** 4th quarter, 57–60).

Three documents on tilt-hammers (*Rev. Histoire Sidér.*, 1960, **1,** 3rd quarter, 33–41) Three sample documents: (1) A notary's inventory of the Villereux Forge in 1591 with detailed description. (2) Notary's royal's description of a visit to the Pinsot Forge in 1752. (3) Description of the Forge at Hayange by Sub.-Lieut. of Artillery Lyantey of Metz, in 1808, grandfather of Marshal Lyantey. All three documents give details, which are extended in 40 foot-notes lf all the parts enumerated with their construction and methods of operation.—S.H.-S.

Sketch of the morphology of the tilt-hammer (*Rev. Histoire Sidér.*, 1960, **1,** 3rd quarter, 9–21).

Inquiry into forges made by the Laboratory of the History of Ironfounding at Nancy (*Rev. Histoire Sidér.*, 1960, **1,** 3rd quarter, 43–52) An exhaustive study, based on rich documentation, supported by sketches and photographs, with details of numerous forges studied in the regions of the Loire, the Dauphiné, Savoy, the County of Nice, and Italy (Piedmont).

The tilt-hammer in [European] museums (*Rev. Histoire Sidér.*, 1960, **1,** 3rd quarter, 53–59).

The origins of the forge [or iron mill] (*Rev. Histoire Sidér.*, 1960, **1,** 3rd quarter, 23–32).

The forge at D'Ablainville P. Grosdidier (*Rev. Histoire Sidér.*, 1960, **1,** 4th quarter, 61–67).

The archives of the Soc. des Hauts Fourneaux et Fonderies de Givors (*Rev. Histoire Sidér.*, 1960, **1,** 4th quarter, 68–70) The archives of the Givors foundry from its establishment in 1841 to its centenary are summarized and their content is described.—S.H.-S.

Algerian minerals and metropolitan ironfounding hopes and realities (1845–1880) B. Gille (*Rev. Histoire Sidér.*, 1960, **1,** 4th quarter, 37–55).

England's first [wooden] rails: a reconsideration R. S. Smith (*Renaissance and Mod. Stud.*, 1960, **VI,** 119–134).

On the history of the Šmeral works V. Šteffek (*Slévárenství*, 1961, **9,** (4), 121–122) [In Czech] The history of the foundry, situated in Brno, is related on the occasion of the 100th anniversary of its foundation.—P.F.

History of the growth of the Iron and Steel Industry in India S. K. Nanavati (*Iron Steel Rev.*, 1960, *Tata No.*, 69–75).

The far-sighted founder [Jamshetji Tata] V. Elwin (*Iron Steel Rev.*, 1960, *Tata No.*, 79–84).

Iron and steel development in India E. Black (*Iron Steel Rev.*, 1960, *Tata No.*, 51–52).

Pierre Chevenard, a great French metallurgist (*Acier Fins Spéc.*, 1960, Dec., 36, 92–100) Obituary notice, summarizing the life and work of Chevenard.—R.P.

ECONOMICS AND STATISTICS

World steel production up to the present and in the future O. Hoff (*Jernindustri*, 1960, **41,** (7/8), 133–135, 149) World steel production up to 1959 is analysed, classified into geographical distribution, and a note on iron ore reserves given.

The next 4-year plan for the French steel industry R. Pitaval and R. Serin (*Mines Met.*, 1961, April, 199) [In French] The French steel industry aims at a crude steel capacity of 249 million tons in 1965. As to process distribution a big increase in production of steel using pure oxygen is forecast from 0% in 1959 to 26·7% in 1965. As to rolling mills two new continuous strip mills will be installed, one at Jollac and one at the new integrated works at Dunkirk. French steel prices are expected to rise to assist in financing the investment programme but as these are 15% less than German prices at present they will still be competitive.

The probable lines of development of the iron and steel industry in Lorraine M. Epron (*Rev. Ind. Min.*, 1961, **43,** March, 157–168).

Steel output in West Germany (*Iron Steel Rev.*, 1961, **4,** Jan., 41–43) A general review: during the eight years from 1952 to 1960 the yearly investment was running around 250 million dollars, not according to a rigid national plan but according to the requirements of the market with high flexibility in the decisions and the operation of individual firms. Examples are given of this flexible policy and the results attained. The relationship between steel consumption and standard of living is discussed and a modification of this is proposed the comparative figures for the various countries being given on this new basis.—C.V.

The growth of the South African Iron and Steel Industrial Corporation and its position within the South African economy C. M. Krüger (*Stahl Eisen*, 1961, **81,** March 2, 277–284) The modern South African iron and steel industry started just before the First World War, in 1928 the present South African Iron and Steel Industrial Corporation was founded. Brief surveys are given of the rolling mills at Pretoria and Vanderbijlpark, of the raw

material sources and of the peculiarities of iron and steel production in South Africa.—T.G.

Metals and engineering in the ECAFE region (*Iron Steel Rev.*, 1961, **4,** Jan., 35–37) Various questions are posed relating to the production of machine tools: should they be produced by specialized units, should such a factory have a foundry as an integral part, should general machine tool production be undertaken or should it be restricted to specialized lines, etc. No answers are given. The production of Al is considered but although bauxite reserves are substantial the capacity of the industry is limited. The markets are considered and a plea is made for greater co-operation between the countries of the region to enter into joint schemes for development and trade.—C.V.

Steel in the ECAFE region (*Iron Steel Rev.*, 1961, **4,** Jan., 11–28) A general review. The tables cover only the 1950–1958 period.—C.V.

Iron and steel in India A. S. Bam (*Iron Steel Rev.*, 1961, **4,** Jan., 39–40) A very general consideration of the present position with the suggested target figures for the future.—C.V.

Durgapur—A technical survey, steel in the public sector J. Pande (*Iron Coal Trades Rev.* 1960, pp.218, 1–6, 10) The main details of the three state steel works (Rourekela, Bhilal, and Durgapur) are given, suppliers, sources of raw materials, water, limestone, etc., capacity and nature of output (plates, sheet and strip, tinplate, rails, heavy forging blooms, wheels, and axles, etc.) and cast being tabulated.—C.V.

Durgapur—A technical survey, ISCON C. E. Jones (*Iron Coal Trades Rev.*, 1960, pp.218, 16–18) The Indian Steelworks Construction Company Ltd, is a consortium of 13 British companies with an independent chairman; the constituent member companies are listed. The general details are outlined.—C.V.

Future demand for steel K. J. Cleetus (*Iron Steel Rev.*, 1960, *Tata No.*, 57–62) The Sales Manager of the Tata Iron and Steel Co. Ltd, reviews the position.—S.H.-S.

Financing steel development [In India] S. K. Choudhury (*Iron Steel Rev.*, 1960, *Tata No.*, 97–102).

The development of a steel industry: factors affecting the economics of steel M. D. J. Brisby (*NML Pilot Plant Symp.*, 1960, July, 53–65) A survey is presented of the scope, resources, growth and range of products required for starting and developing a steel industry, with data on siting of steelworks, economics of size, capital costs, and returns on investments, with nine tables, six figures, and a consolidated appendix, concluding with a brief discussion.

The steel industry metals. Iron ore G. A. Schnellmann (*Min. J. Ann. Rev.*, 1960, May, 31–32) The world output for the 23 chief producers of iron for 1958, 1959, and 1960 is tabulated, and attention is drawn to the increasing availability of previously unworked ore fields, such as the Quebec-Labrador, with reference to possibilities in Brazil, the Sahara, and China. **Steel** J. Hetherington (32–33) The world's steel production for 1960 is briefly surveyed and output figures for 1959 and 1960 for leading producers is tabulated, with reference to the United Nations Steel Committee's long-range estimate of the position of world consumption between 1972 and 1975 and especially to predicted increases in India and China. **Manganese** S. Bracewell (33–35) The fairly constant ratio of about 23: between world crude steel production and manganese ore consumption is reviewed, and consumption figures and prices of manganese ore in leading world markets are surveyed. **Nickel** A. G. Thomson (35, 37) A survey of the 'Free World' production and exploration of Ni, with particular reference to increased Canadian output, and data on markets and usage, together with an assessment of the short-range outlook is presented. **Chromium** A. G. Thomson (39–40) World production and consumption of Cr are statistically reviewed and the outlook for consumption in 1961 is briefly discussed. **Cobalt** (37, 39) Cobalt production for 1958, 1959, and 1960, is tabulated by countries in t of contained Co and use pattern is reviewed in the light of the Bureau of Mines statistics for the US. Its increasing use as an alloying element in steels other than tool steels is stressed and examplified. **Tungsten** P. E. Grainger (40–41) The possession of the bulk of the world's known reserves of W by the Communist areas is mentioned and the effect of production from these countries is compared with that of other world producers. Prices and markets are reviewed and prospective production from a major discovery in the Canadian North-West Territories to a point of 300 s.t. per day by the end of 1961 is suggested. **Molybdenum** (41–42) Data on world production and consumption of Mo are presented and discussed, in the light of the fact that over 90% of the world's known deposits lie in the Western US, where a large deposit is reported as discovered at Questa, New Mexico. **Vanadium** (41) Prospective use of V_2O_5 as a catalyst for automobile smog control is briefly discussed. Data on world production and consumption are presented, but current production statistics of US vanadium ores, which account for approximately 75% of world output, are withheld. **Columbium and Tantalum** J. Sandor (43, 44) World prices of columbite and tantalite are reviewed. World production of the minerals is surveyed. A new process for the production of Nb metal announced during 1960 by Battelle Memorial Institute is discussed, and other technological progress in the use of the metals is recorded, including the use of Ta catalyst in the production of synthetic diamonds.—S.H.-S.

New expansion of the French steel industry M. J. Ferry (*Mines Met.*, 1960, Nov., 633–634).

Allocations of overheads in sheet metal working J. W. Langton (*Sheet Metal Ind.*, 1961, **38,** May, 331–333).

Operational research in a steel plant S. Viswanathan (*Iron Steel Rev.*, 1960, *Tata No.*, 181–184) A review.—S.H.-S.

Durgapur—A technical survey. Materials balance (*Iron Coal Trades Rev.*, 1960, pp.218, 27–31) This is based on 1 million ton ingot production; scrap available for the OH furnaces will amount to 18½% and about 850000 t basic iron per annum will be needed. Each of the three blast-furnaces will be capable of producing 1250 t iron daily and the coke requirements are shown and the coke ovens are discussed. The water requirements are reviewed and the distribution is diagrammatically shown.—C.V.

India moves forward S. Swaran Singh (*Iron Steel Rev.*, 1961, **4,** Jan., 29–33) A general summary of the work accomplished leading up to the third Five-Year plan which is aimed at bringing steel production up to 10^7 t by March 1966 of ingot steel. The ferro-manganese industry and the production of non-ferrous metals are also mentioned.—C.V.

Forecast of Japanese iron and steel demand in 1970 (*Iron Steel Rev.*, 1961, **4,** Jan., 45–51).

Columbium steels are gaining fast T. H. Spencer (*Steel*, 1961, **148,** May 8, 157–158).

The Canadian mineral industry 1957 (Mineral Report 2) W. K. Buck (*Can. Mines*, 1960, M38–5/2, pp.491).

MISCELLANEOUS

Excitation functions for alpha-particle reactions on ^{56}Fe and ^{57}Fe S. Tanaka, M. Furukawa, S. Iwata, M. Yagi, H. Amano, and T. Mikumo (*J. Phys. Soc. Japan*, 1960, **15,** Dec., 2125–2128).

Determination of equilibria between CO–CO_2 mixtures and γ-mixed crystal, cementite and graphite E. Scheil, T. Schmidt, and J. Wünning (*Arch. Eisenh.*, 1961, **32,** April, 251–260) Studies of the equilibria between CO/CO_2 mixtures and γ-mixed crystal, cementite, and graphite have produced data which are in good agreement with data in literature. Exception was the composition of 0·76%-wt at the pearlite point. The mp of ledeburite was found at 1150°C (19 refs).—M.L.

Control in the iron and steel industry A. Roos (*Mét. Constr. Mécan.*, 1961, **93,** April, 313–319).

An improved assessment of performance and consumption data in iron and steel works H. H. Plugge (*Stahl Eisen*, 1961, **81,** March 30, 408–421).

Durgapur—A technical survey K. Sen (*Iron Coal Trades Rev.*, 1960, pp.218, 7–10) A brief description of the district, its development and facilities is given.—C.V.

Durgapur—A technical survey. The United Kingdom steel mission to India E. Coates (Sir) (*Iron Coal Trades Rev.*, 1960, pp.218, 12–13) The terms of reference are given. The general programme was fully endorsed but difficulty was encountered over the estimates of costs. Three paragraphs dealing with suggestions are given verbatim and the names of those serving on the mission are given.—C.V.

Durgapur—A technical survey. Co-ordination of the contract W. S. Hindson (*Iron Coal Trades Rev.*, 1960, pp.218, 19–22) A general review; the names of the member companies responsible for the supply of the different sections and the sub-contracting companies are listed.—C.V.

Durgapur—A technical survey. Housing and welfare Durgapur Steelworks (*Iron Coal Trades Rev.*, 1960, pp.218, 209–210) Since the whole site was created from virgin jungle and some 30000 workers are now in the area it will be appreciated that the provision of services and facilities was no mean task. The township is about 3 miles and a bus service is provided.

Durgapur—A technical survey. Trained in Britain Durgapur Steelworks (*Iron Coal Trades Rev.*, 1960, pp.218, 216–218).

The importance of noise measurement for an effective noise abatement in iron and steel works G. Schulz (*Stahl Eisen*, 1961, **81,** Feb. 16, 220–228).

Steel production with safety F. R. Barnako (*AIMME, Proc. OH Comm.*, 1960, **43,** 28–32).

Safety in steel production E. L. Wentz (*AIMME, Proc. OH Comm.*, 1960, **43,** 33–40).

An effective safety program P. F. Adams (*AIMME, Proc. OH Comm.*, 1960, **43,** 40–47).

Safety program at Colorado Fuel and Iron Company G. Grosvenor (*AIMME, Proc. OH Comm.*, 1960, **43,** 47–48).

Safety procedures at Lone Star Steel Company S. M. Purcell (*AIMME, Proc. OH Comm.*, 1960, **43,** 49–51).

Epitaxis of crystals of nickel and of iron formed by reduction in the gas phase of nickel chloride and ferric chloride and deposited on cleavages of crystals of alkali halides and miscovite L. Capella (*Compt. Rend.*, 1961, **252,** May 29, 3465–3466).

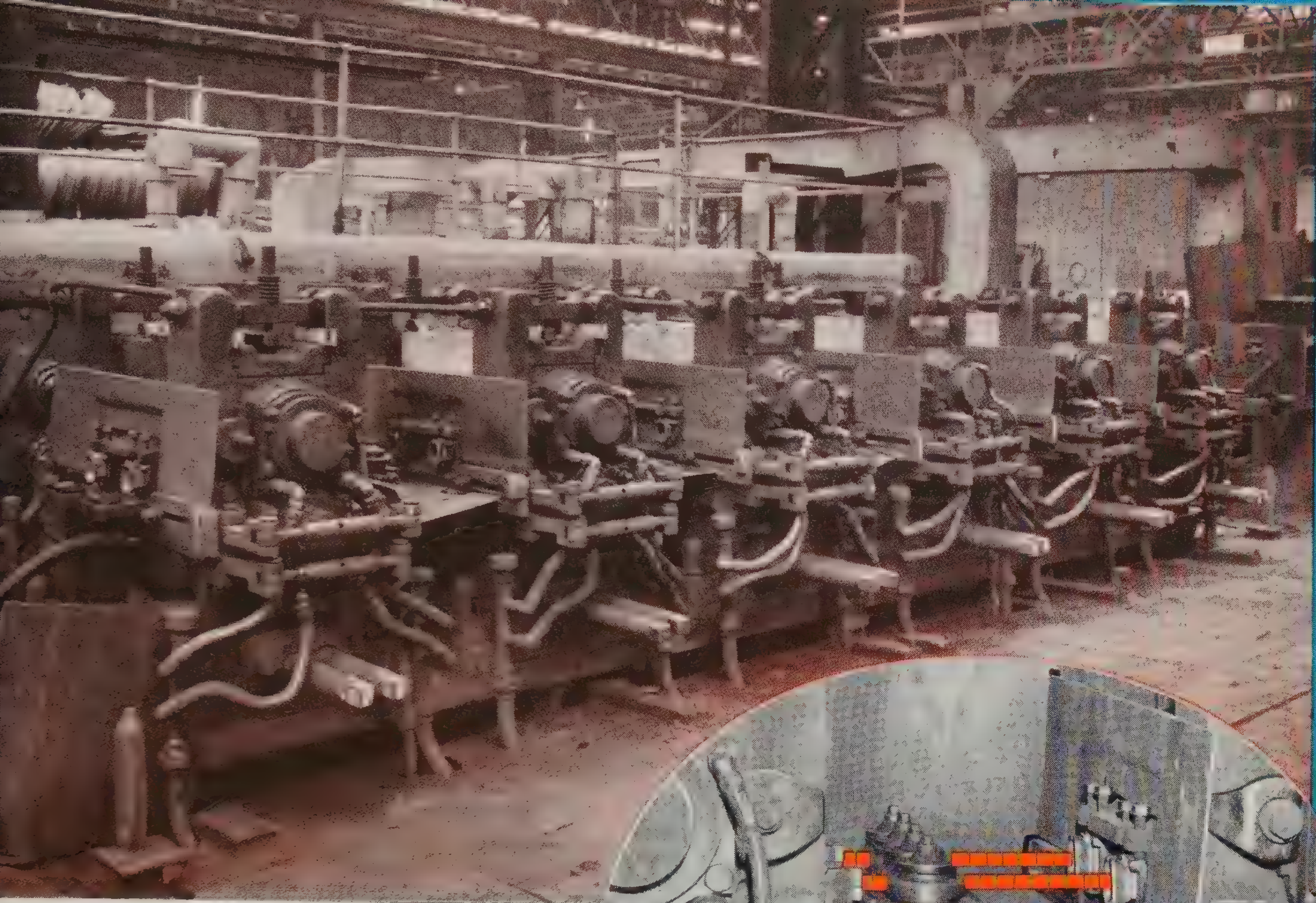
Potential nonnuclear uses for depleted uranium H. W. Nelson and R. L. Carmichael (*USAEC Tech. Inf. TID*–8203, 1960, Jan. 29, issued 1960, July, pp.58).

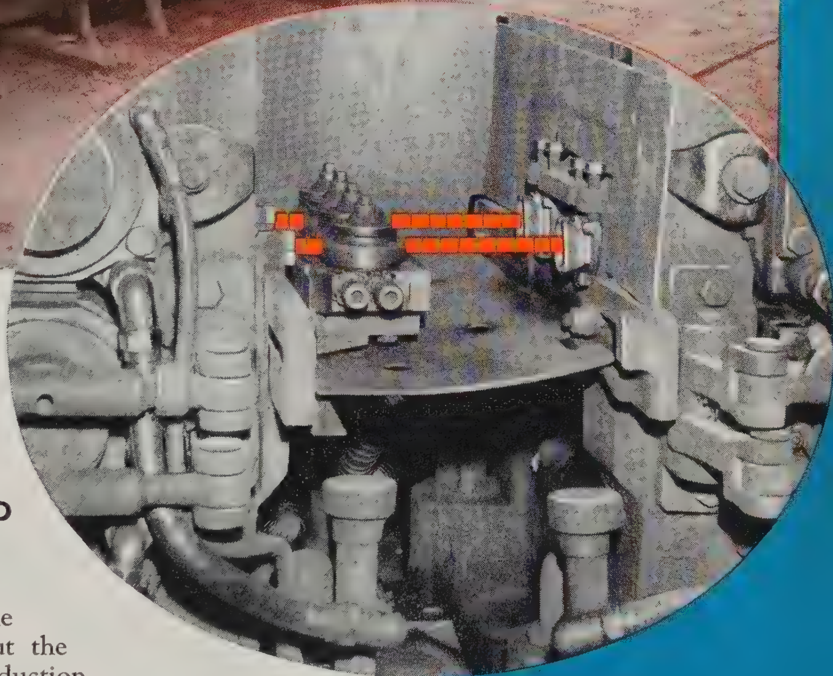
Recovery of vanadium pentoxide from vanadium bearing titaniferous magnetites projected pilot plant studies B. K. Agrawal, M. P. Menon, and P. P. Bhatnagar (*NML Pilot Plant Symp.*, 1960, July, 182–187).

Electrowinning molybdenum: preliminary studies H. J. Heinen and J. B. Zadra (*US Bur. Mines Rep. Invest.*, 5795, 1961, pp.14).

Behaviour of some impurities in the electric-refining of iron T. Mukaibo (*Ann. Rep. Eng. Res. Inst. Univ. Tokyo*, 1960, **19,** Sept., 38–41) The behaviour of PO_4-ion, SO_4-ion, and Zn ion in the Mohr's salt bath and of silver plated on anodes were studied by using P-32, S-35, Zn-65 and Ag-110 as radioactive tracers. Phosphate ion was found to deposit on the cathode like a cation as shown in Fig.1a, Fig.1b, and Table I. The effect of washing on the S contents of the deposited metal is illustrated in Fig.2. Ag was eliminated effectively by electrolysis, however some difficulties were expected in removing zinc from iron by electrolysis.—C.F.C.

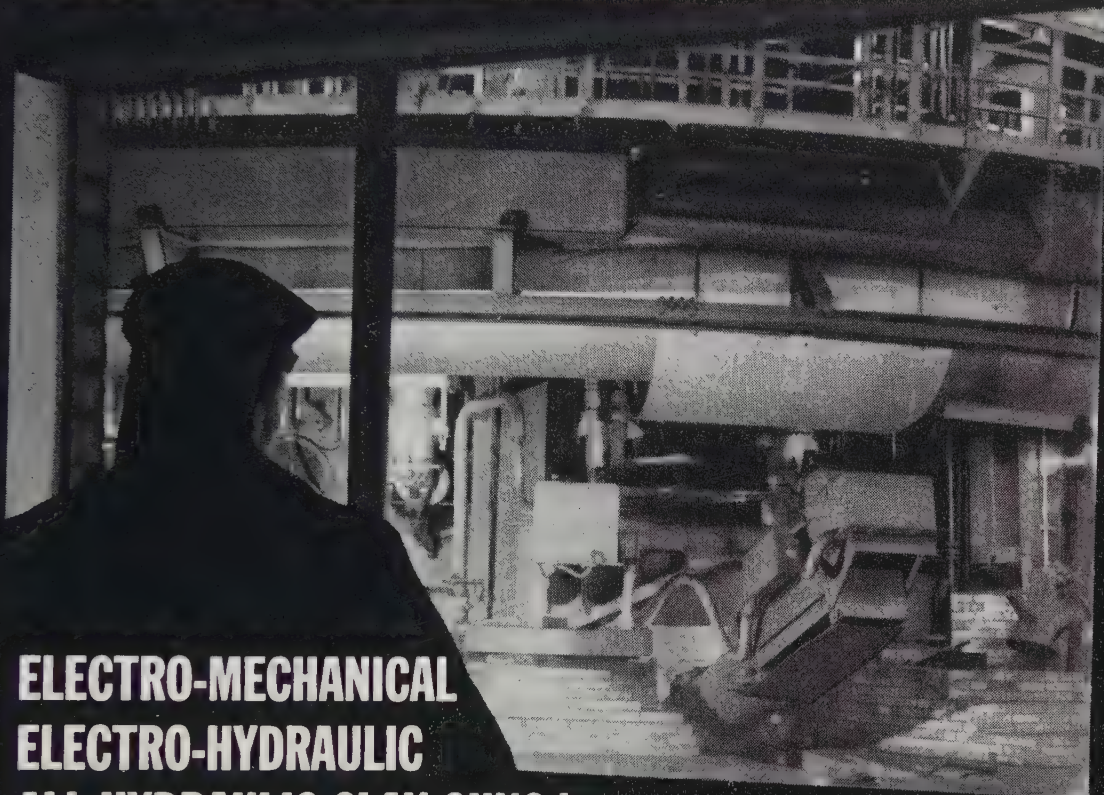
Coherent mechanism of lead on iron and steel Y. Mayazaki and R. Kawabata (*J. Japan Welding Soc.*, 1960, **29,** Aug., 629–632; from *Japan Sci. Rev. Mech. Elect. Eng.*, 1961, **7,** Feb., 556) [No abstract].—C.F.C.





2700 TAP HOLES

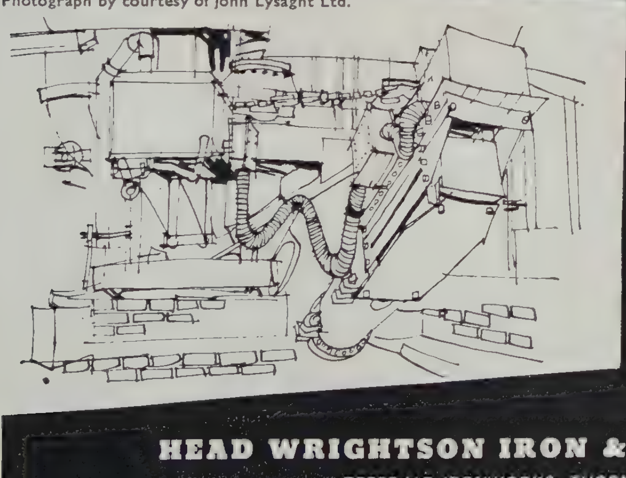
and no maintenance necessary



ELECTRO-MECHANICAL
ELECTRO-HYDRAULIC
ALL HYDRAULIC CLAY GUNS by

HEAD WRIGHTSON

Photograph by courtesy of John Lysaght Ltd.



An electro-hydraulic gun recently installed at Cargo Fleet Ironworks for tests, stopped 2,760 tap holes without any maintenance during this period.
The electro-hydraulic guns are readily interchangeable with mechanical units, and it is possible to fit the electro-hydraulic gun and still retain the electrical controls fitted for mechanical guns should these be required as standbys.
For full details of tests made on these guns, and any other information, please contact:
Sales Manager

HEAD WRIGHTSON IRON & STEEL WORKS ENGINEERING LTD.

TEESDALE IRONWORKS, THORNABY-ON-TEES, YORKS. Telephone: Stockton 62241

P6213

America, Pickford Holland are now making to-day's most successful basic roof keys

The P.H. Ferrobond CMX 3″ x 3″ Roof Key is a new, metal-clad, chemically bonded basic open-hearth brick without internal plates, designed by E. J. Lavino & Co. of Philadelphia for maximum service and economy. A series of comparative tests with internally plated 4½″ x 3″ keys proved Ferrobond to be always equal, and usually superior, in performance. They are light and easy to handle, have built-in hot face expansion, and tabs ensure correct alignment. In addition, saving on material cost by rib and valley construction makes the P.H. Ferrobond beyond doubt today's outstanding value in basic roof brick. Considering a trial? Send drawings of your present roof to Pickford Holland who will redesign to suit Ferrobond bricks, and give you the assistance of a service engineer for installation.

See how split-roof tests prove OUTSTANDING PERFORMANCE by new FERROBOND ROOF KEYS

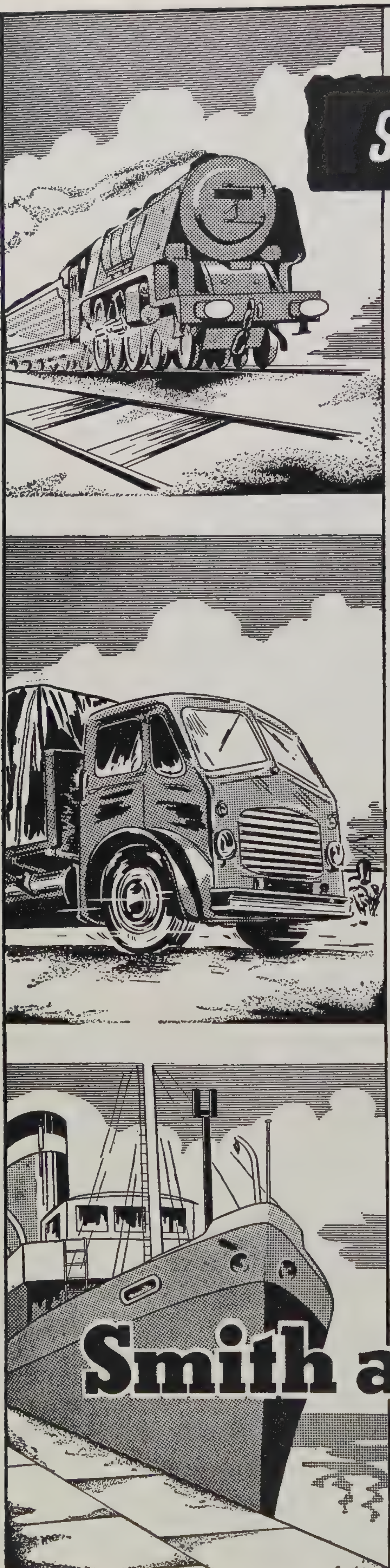
Furnace Capacity	Construction of Roof	Campaign Life	Total Tonnage Produced	Tons/Hour	% AREA PATCHED: Lavino Ferrobond CMX 3″ x 3″ Keys	% AREA PATCHED: Metal Cased Internally Reinforced 4½″ x 3″ Keys	Oxygen Lances through Roof
190 Tons	12″ Rib 9″ Valley	284 Heats 112 Days	54,000 Tons	20	1.0%	1.6%	2
190 Tons	12″ Rib 9″ Valley	250 Heats 75 Days	47,500 Tons	26	2.2%	12.6%	2
190 Tons	All 12″	405 Heats 130 Days	77,000 Tons	25	62%	67%	2
200 Tons	15″ Rib 12″ Valley	488 Heats 196 Days	100,000 Tons	21	2.8%	6.6%	NONE
345 Tons	15″ Rib 12″ Valley	453 Heats 170 Days	157,000 Tons	38.5	10.4%	19.0%	2
400 Tons	15″ Rib 12″ Valley	298 Heats 186 Days	120,000 Tons	27	NIL	NIL	2

This chart shows comparative performance records in North America of six typical open hearth roofs. In each case the roof was constructed half-and-half of Lavino Ferrobond CMX 3″ x 3″ Roof Keys and Internally Plated 4½″ x 3″ Roof Keys. All were of the Fairless type roof construction (hold-up, hold-down). Production rate of tons per hour is based on total production over campaign time, and includes repair times, fettling times, and all lost time whatever the cause.

P.H. Ferrobond Roof Keys are manufactured under licence from E. J. Lavino & Company, Philadelphia, U.S.A. by

PICKFORD HOLLAND

PICKFORD, HOLLAND & COMPANY LIMITED, 381 FULWOOD ROAD, SHEFFIELD 10, TEL: 33921



Steel Mill automatic control gear

Contactor Switchgear Limited manufacture automatic electric control gear up to 6,600v. A.C. and 650v. D.C. for Iron and Steel Works, Power Station Auxiliaries, Rolling Mills, Mechanised Foundries, Sewage Works, Chemical Plants, Gas Works and Cement Works; including Cranes, Electric Furnaces, Machine Tools, Fans and Pumps, etc.

The illustration shows open type control gear installed for control of Blooming Mill auxiliary drives at Stewarts and Lloyds, Limited, Bilston.

May we receive your enquiries for automatic control gear . . . our technical advisory service is at your disposal.


Most resistant to attack by hot metal and slag
Very resistant to thermal shock
It's accurate in shape and size
Extremely tough and robust
We have proved for ourselves that MARSHALL **SLEEVES** are really reliable
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One of the MARSHALL REFRACTORIES GROUP of Companies

and so
a sinter plant is built

TODAY

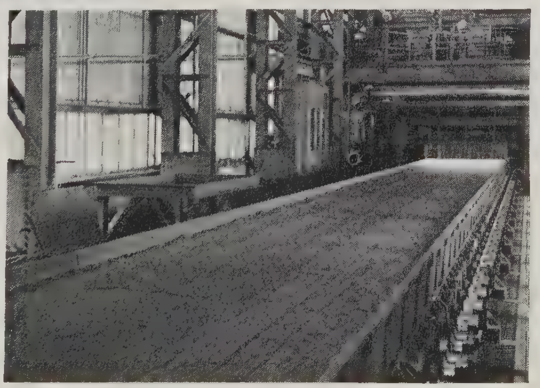
The blast furnaces are consuming the full output of the sinter machine HH installed as part of the expansion programme at the Gartsherrie Works of Bairds & Scottish Steel Ltd.

TOMORROW

To cater for the future, the plant was designed so that a second sinter machine, although located away from the first strand, can receive raw materials from the same feed system.

ALWAYS

HH sinter plants are built to suit individual conditions so that every client obtains maximum benefit from progressive design. Precise control of the mix, the special forced draught cooler and a very adaptable stockyard arrangement are but three of the many specialities that make HH plants such economical producers of high quality sinter.



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HH35/SP

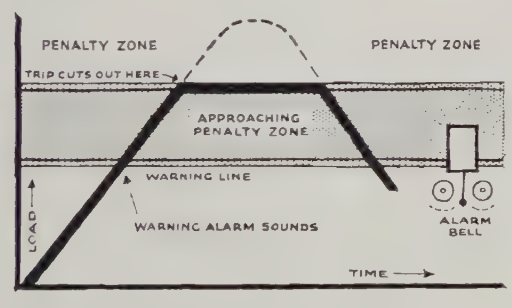
Load Factor Improvement

Most industrial electricity tariffs consist of a fixed charge based on the maximum demand for electricity by the works and a running charge for each unit (kWh) of electricity used. Broadly speaking, the fixed charge covers the capital cost of generating, transmitting and distributing equipment for the particular demand and the running charge covers the cost of generating the units.

Thus, if the factory maximum demand is reduced for the same level of consumption or is held constant for an increased consumption, the cost per unit will be reduced. This is termed improving the 'load factor': load factor being defined as the ratio of the number of units supplied during a given period to the number of units that would have been supplied had the maximum demand been maintained throughout the period; it is usually expressed as a percentage. Some ways in which load factor can be improved are:

SUPERVISION AND CONTROL OF MAXIMUM DEMAND

A maximum-demand alarm gives a warning when the maximum demand is about to be exceeded. One of the simplest devices has two warning contacts, but, as a useful addition, an auxiliary relay can be supplied so that non-essential load can be tripped automatically.



The Load Limiter, an automatic device, meets the requirements of medium and large consumers who wish not only to control their system loading to some target maximum but also to improve the load factor in order to increase the overall economy of the plant.

EXAMPLES OF REDUCTION IN MAXIMUM DEMAND

Broadly speaking, loads which contain some storage element can be transferred from on-peak to off-peak times. Examples are: charging electric batteries used in industrial trucks and road vehicles; pumping loads in drainage schemes; water pumping in quarries, gravel pits and other open-air workings; large cold-storage warehouses; ice-making factories in which cost of power is a sufficiently large item of the operating expense to make a reduced charge acceptable.

Many processes at times of peak demand can, under controlled conditions, tolerate a temporary reduction, or even cessation, of supply without any serious effect on the product. With electro-chemical processes such as in the manufacture of hydrogen peroxide no difficulty arises from periodic interruptions at short or even no notice.

In a plastics factory the management arranged for dies to be switched on by time switches one after another early Monday morning so at the beginning of work all dies had reached their operating temperatures. Previously they were switched on more or less simultaneously by hand when work started, resulting in an abnormally high demand.

In a certain chemical works compressed air is used for blowing out containers for plastic material. The nature of this operation is such that the consumption of air is spasmodic and irregular. The demand-recording meter in this works showed that the 18-kilowatt motor driving the air compressor was frequently cutting in on top of the factory load, thus incurring a higher maximum-demand charge. In this case all that was necessary was to ensure that the air receiver only required charging at night-time or at other off-peak times. It was found that the existing receiver had such a small capacity that the pump had to operate to recharge it almost every time the blowing operation took place. This small receiver was therefore replaced by a receiver of large enough capacity to maintain the blowing requirements over the peak periods without further charging.

EXAMPLES OF INCREASED CONSUMPTION FOR THE SAME MAXIMUM DEMAND

Often when the requirements of a factory are studied it is found that there are additional processes for which electro-heat can economically be employed because furnaces or other equipment can be arranged to be switched off or to take a reduced load during periods of peak demand. A sheet metal foundry with an early morning peak found that it would be an economical proposition to use an infra-red oven switched on after the peak period had passed because such ovens are ready for use in a few minutes. The possibilities of electric space heating in this respect are dealt with in Data Sheets 18 and 19.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. Telephone: TEMple Bar 9434.

Excellent reference books are available on electricity and productivity (8/6 each, or 9/- post free) — 'Higher Industrial Production with Electricity' is an example.

E.D.A. also have available on free loan in the United Kingdom a series of films on the industrial uses of electricity. Ask for a catalogue.

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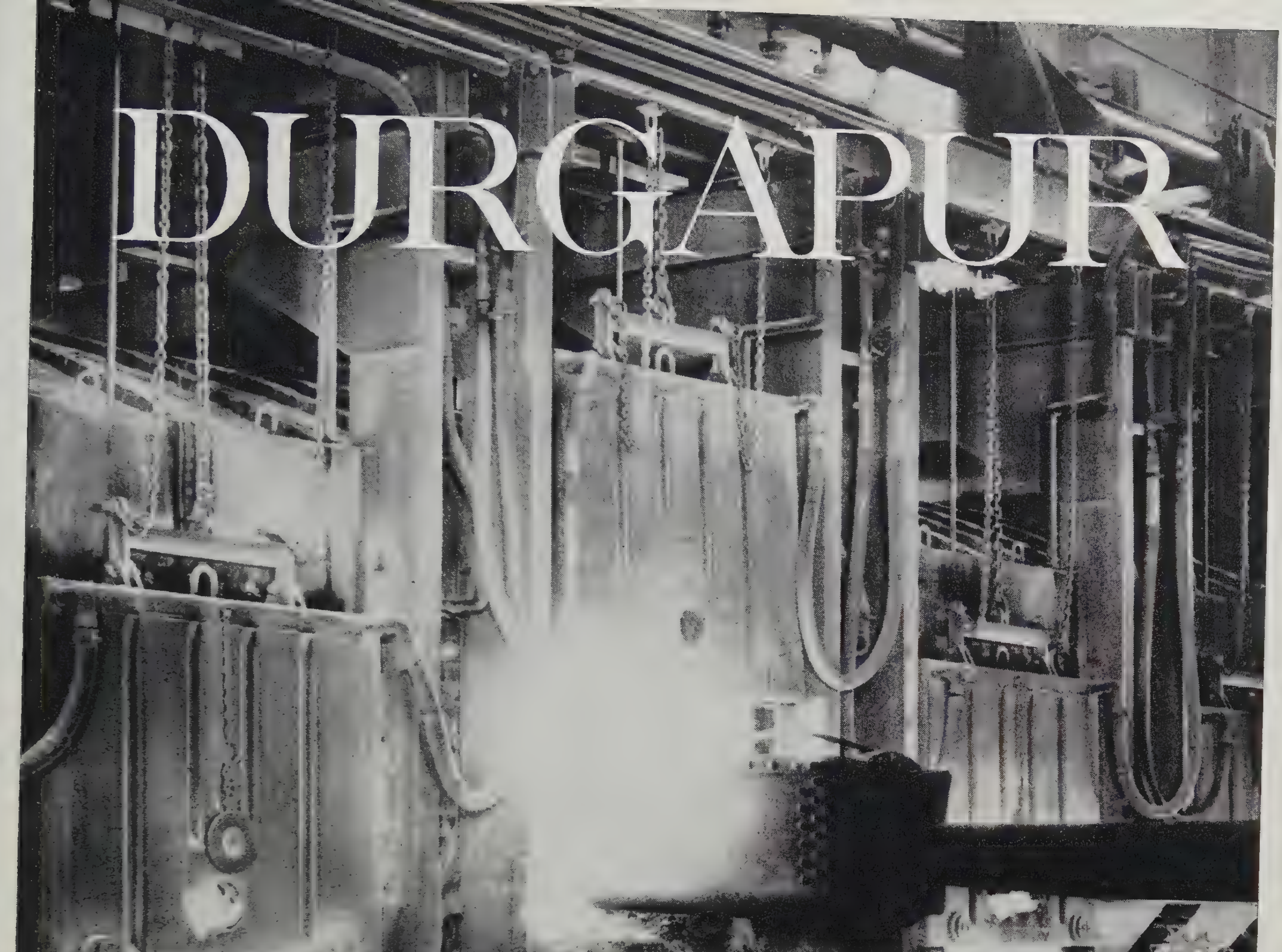
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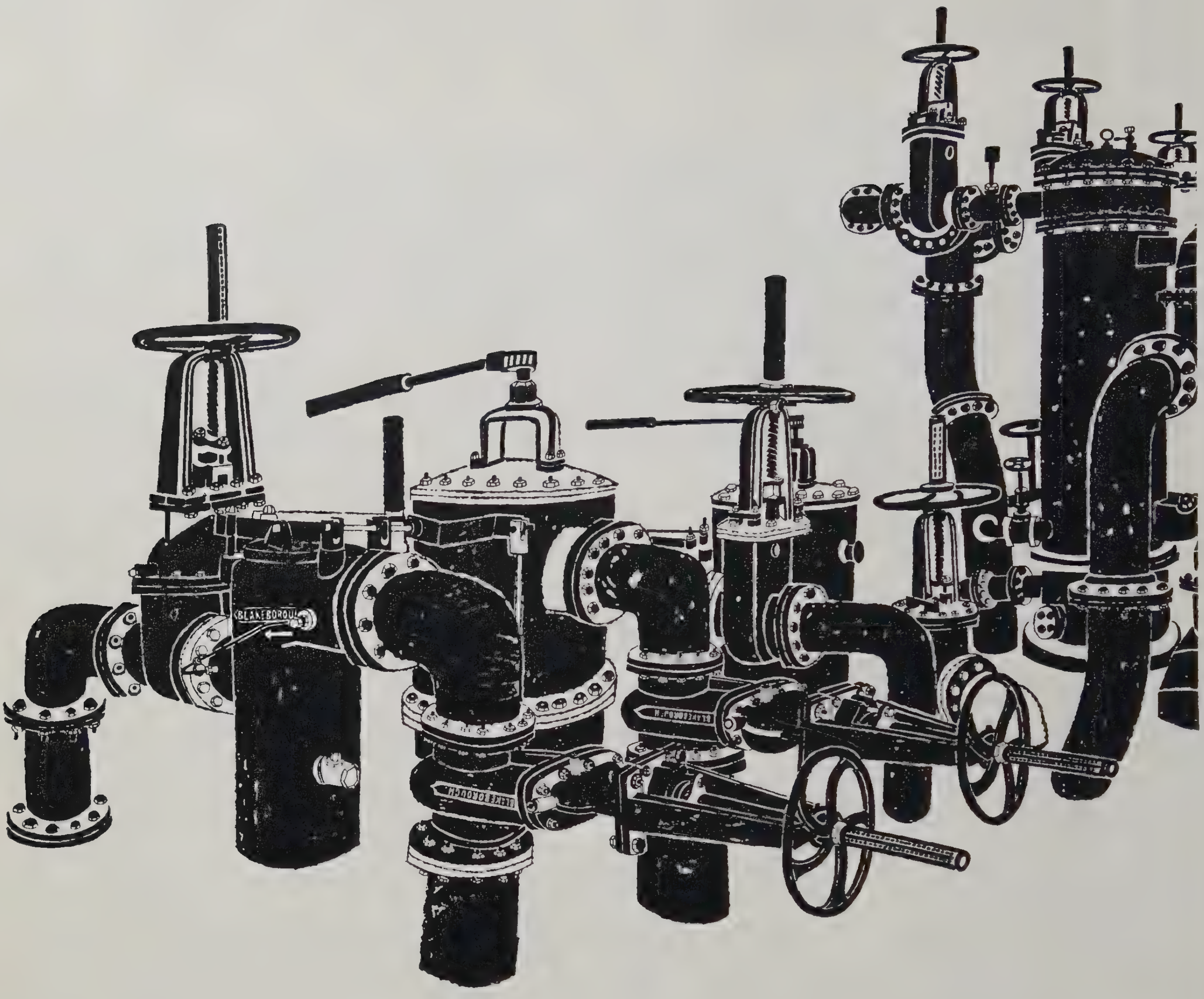


PANTIN
heavy-duty handling systems
Pantin design and manufacture heavy duty mechanical handling plant for the Iron and Steel Industry.
This 'Upender', for example, was made to simplify and expedite the handling of coiled steel. With the utmost ease it takes coils up to 15 tons (max. dimensions 6′ diam. × 6′ wide) and lays them on a Pantin Pallet Conveyor for movement to the next station.
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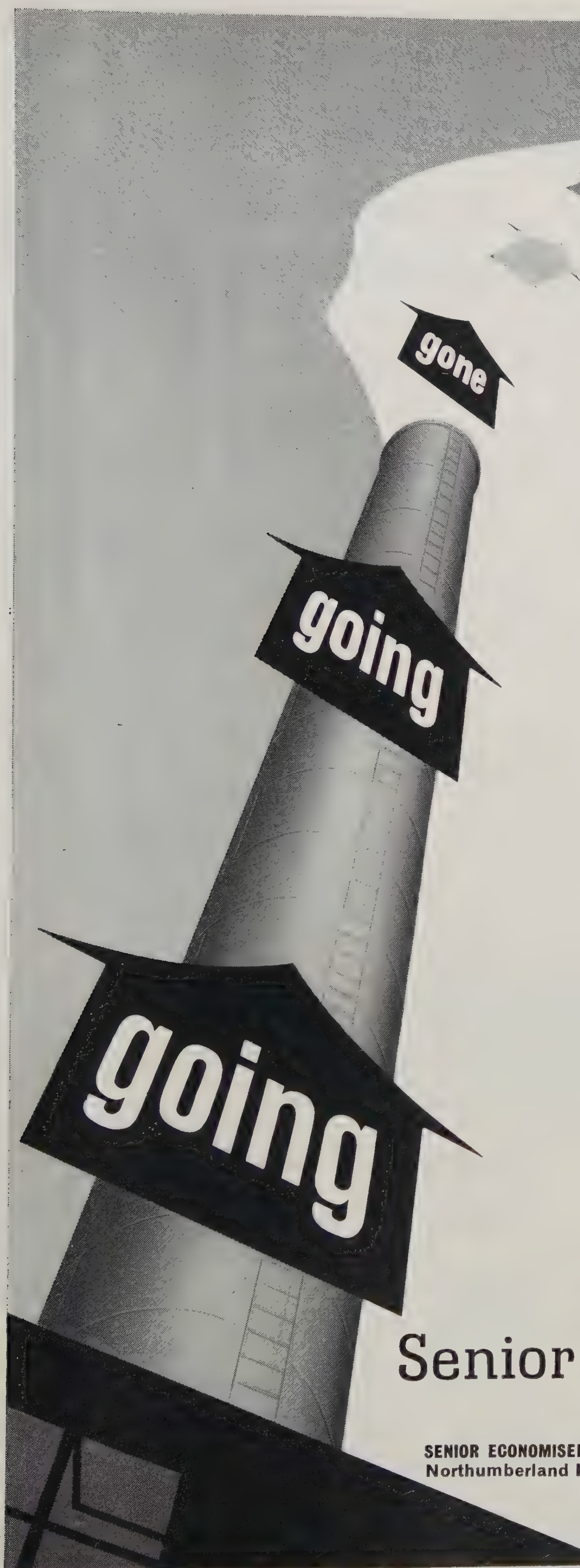
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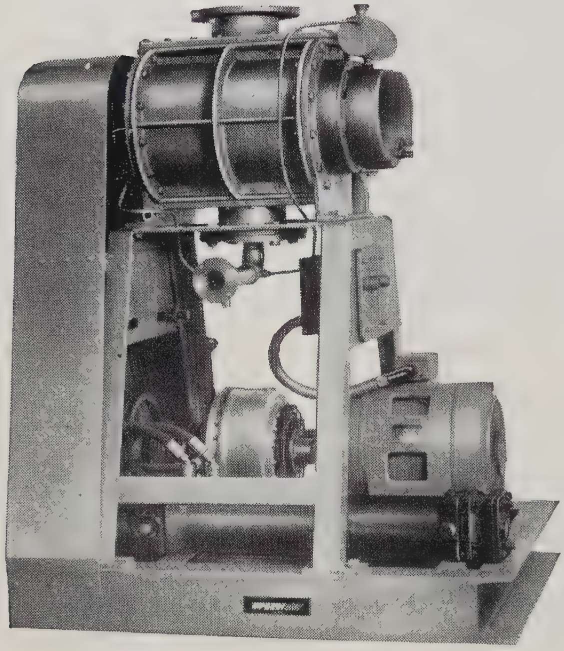

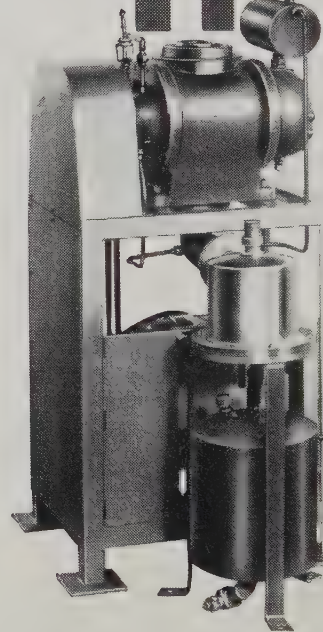

Pump Series Number	Normal Backing Pumps	Permanent Gas Ultimate Vacua Depending on Backing Pump (S) = Single Stage (C) = Combination (SG) = Single Stage With Full Gas Ballast			Theoretical Displacement per rev	Maximum Rev/min (Varies with pressure)	Peak Air Speed Depending on Backing Pump		
		torr (S)	torr (SG)	torr (C)	ft^3		l/sec	ft^3/min	m^3/hr
1R5					0·16	2000			
	1SC450						85	180	305
		$<5\times10^{-4}$	$<2\times10^{-2}$	$<10^{-4}$					
	1SC900						105	220	375
1R35					1·15	2000			
	1SC3000						611	1300	2210
	2×1SC3000	$<5\times10^{-4}$	$<2\times10^{-2}$	$<10^{-4}$			813	1730	2941
	1SC3000*						660	1400	2380
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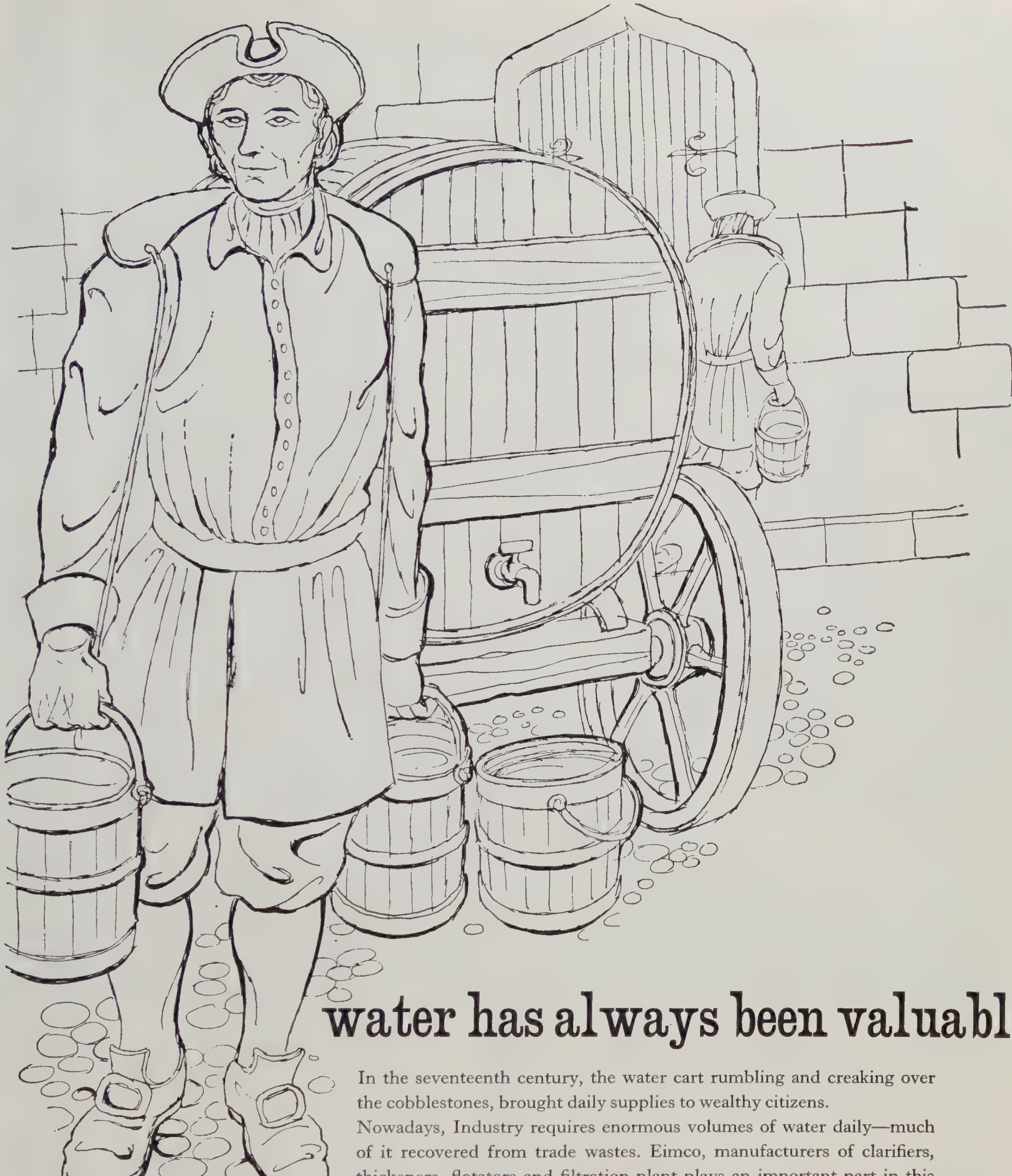

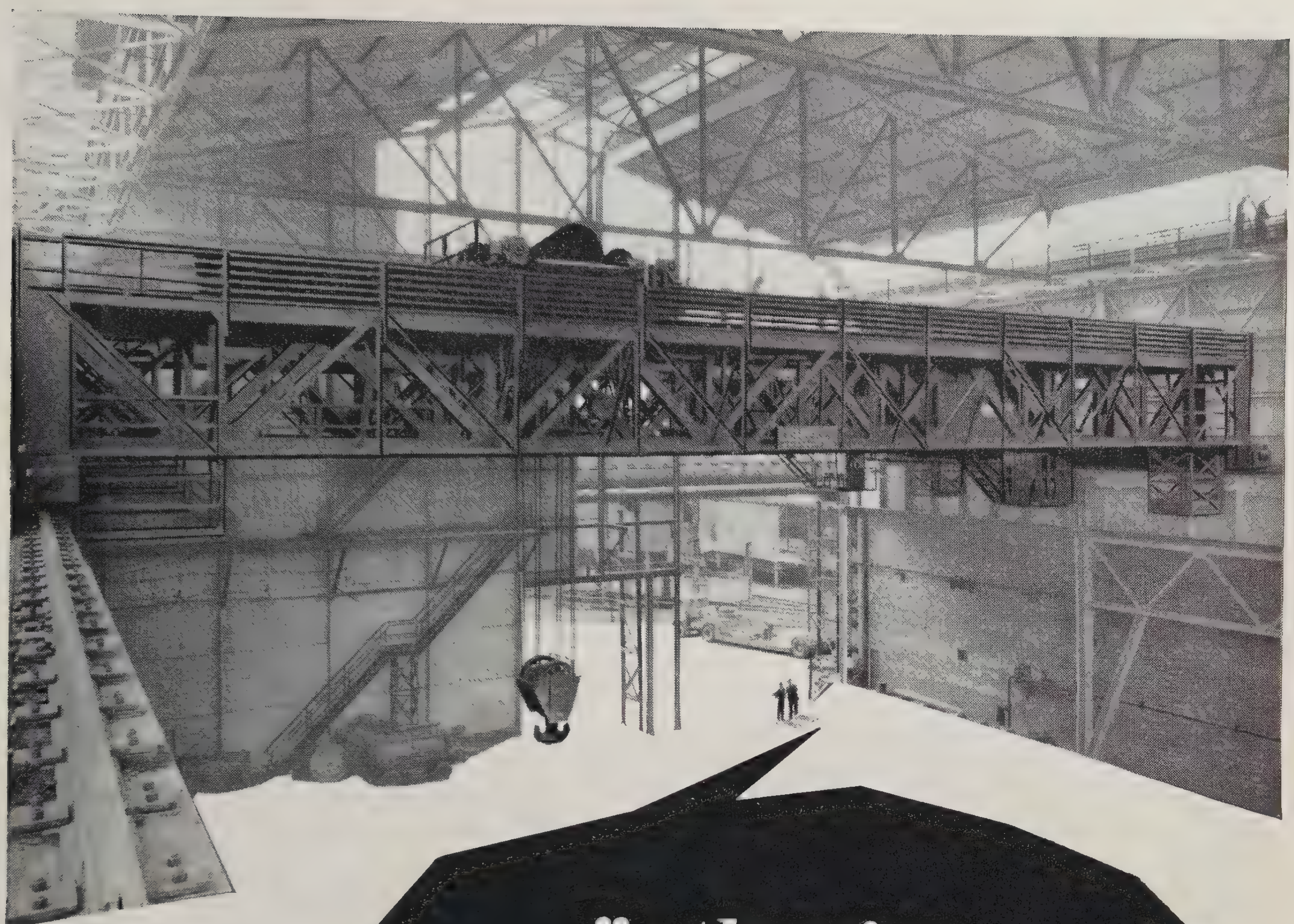

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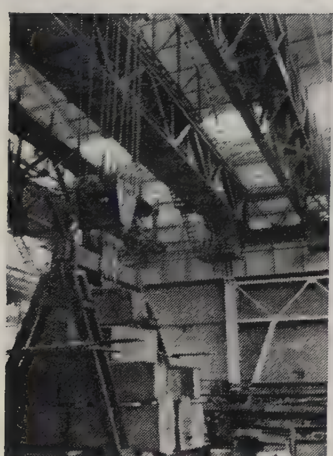

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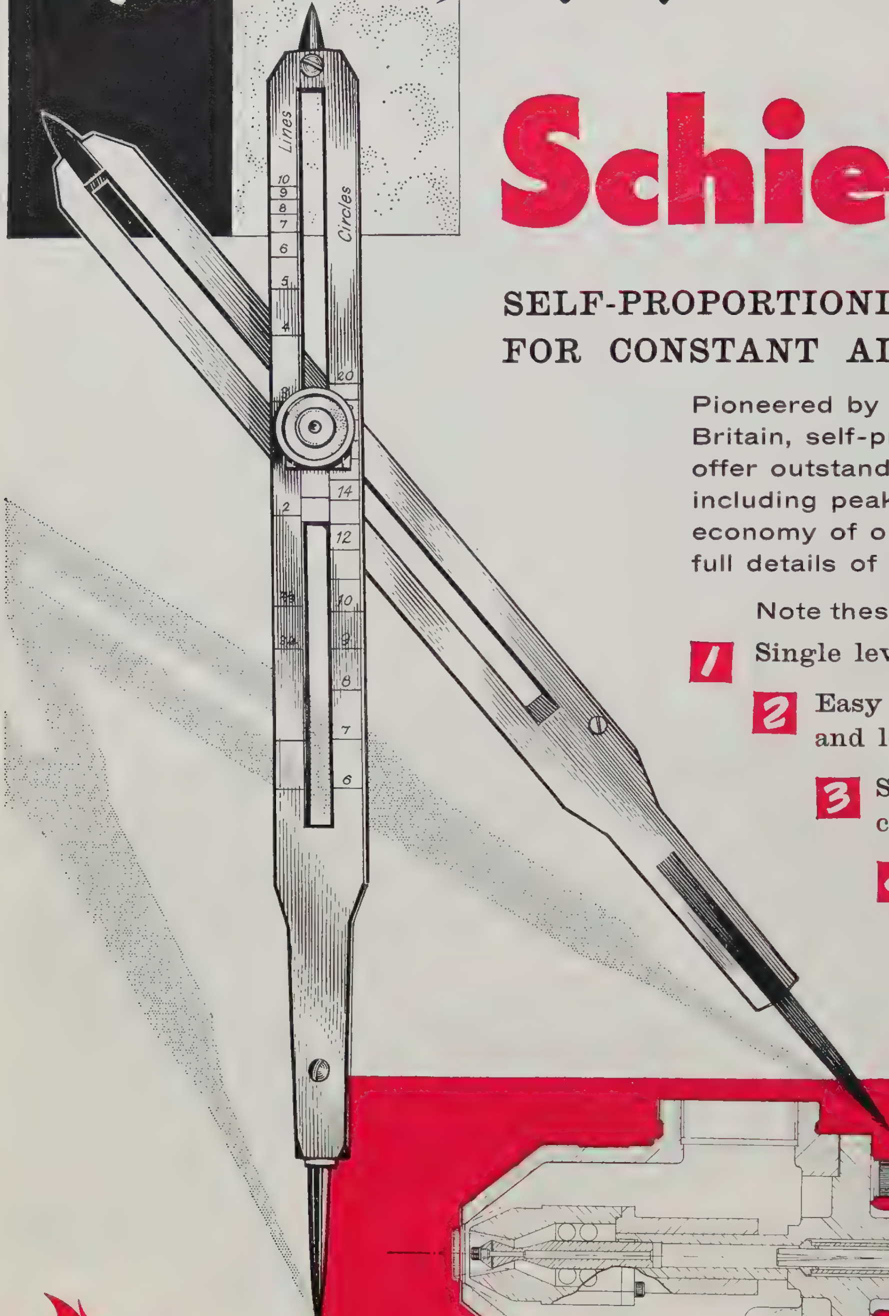

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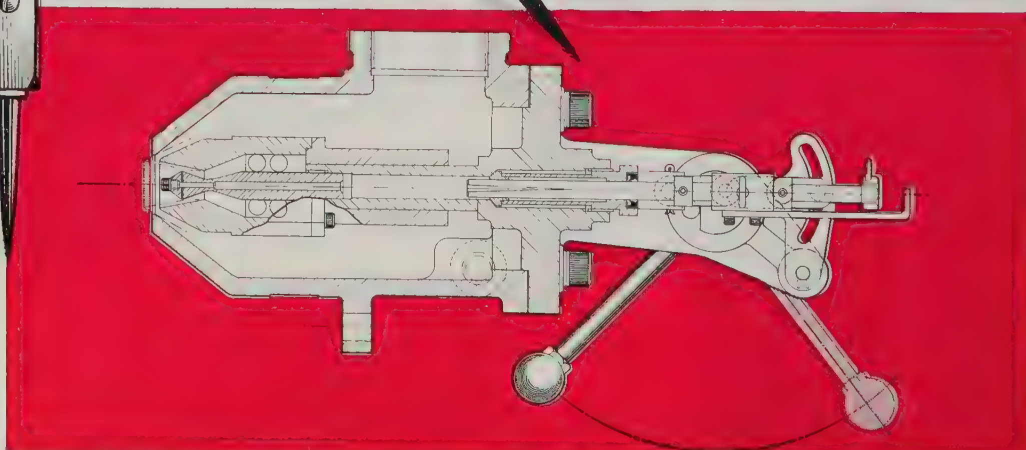

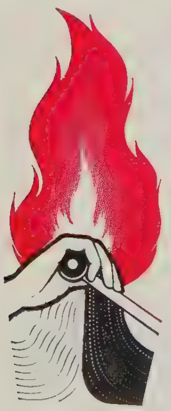

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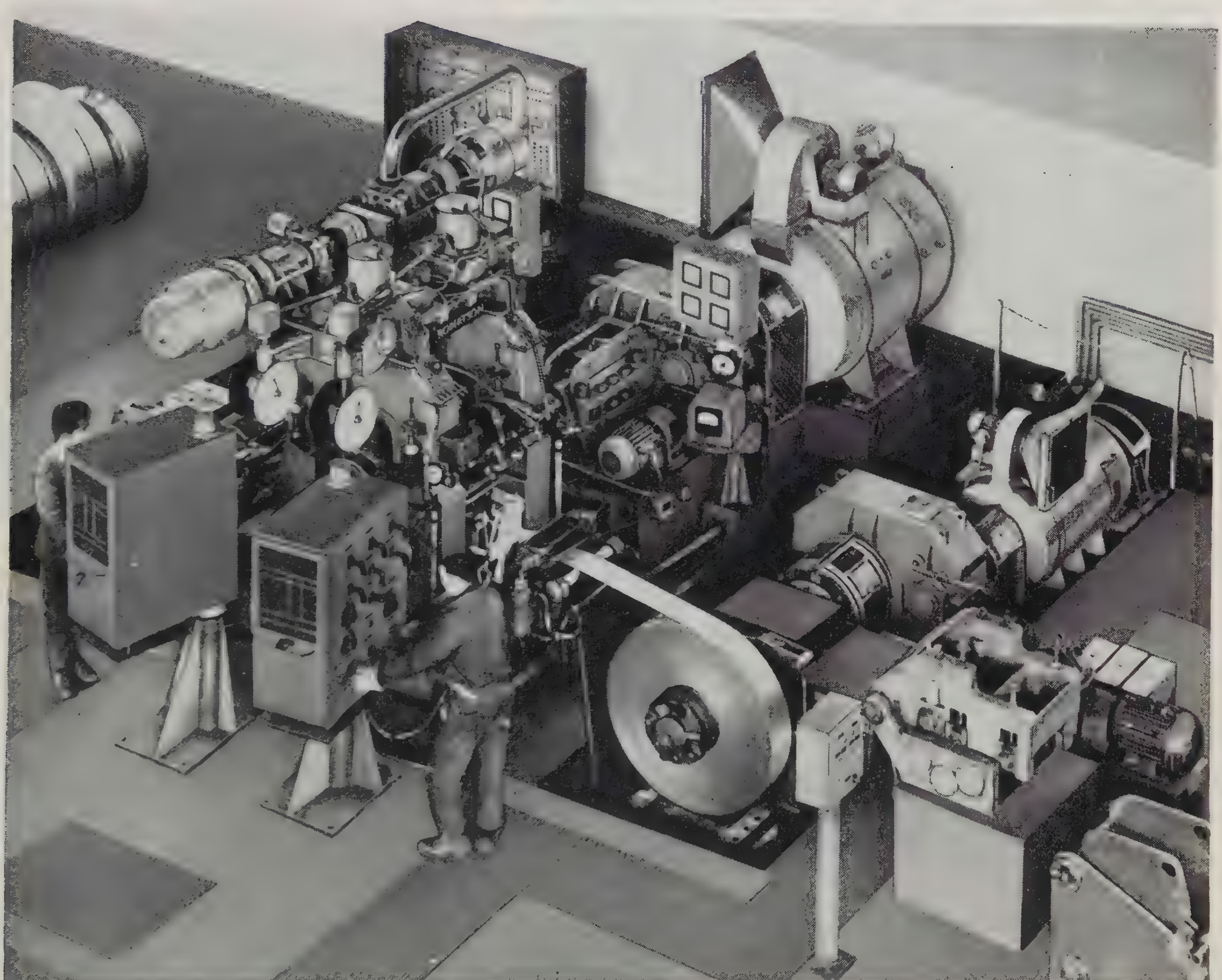

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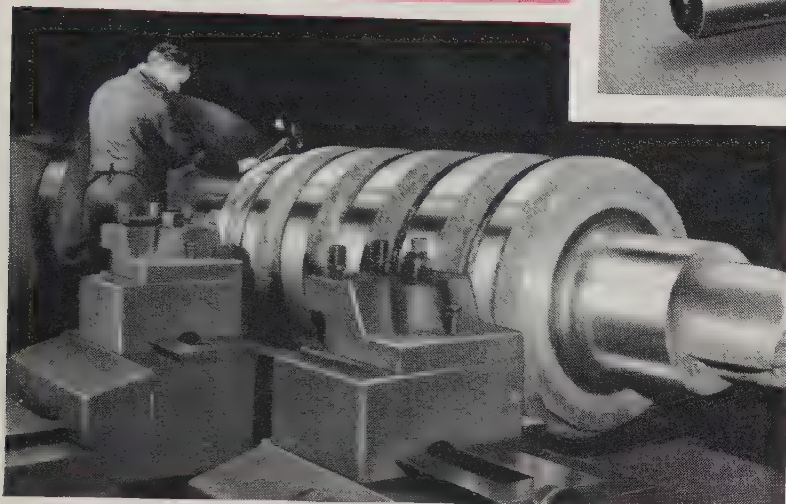
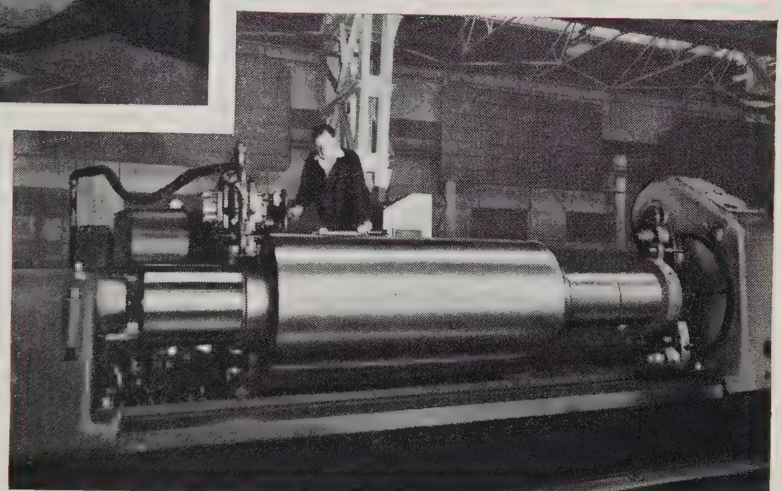


Finishing Roll for a Heavy Structural Mill.



Grinding a Chilled Hollow Roll for a Rubber Callender.

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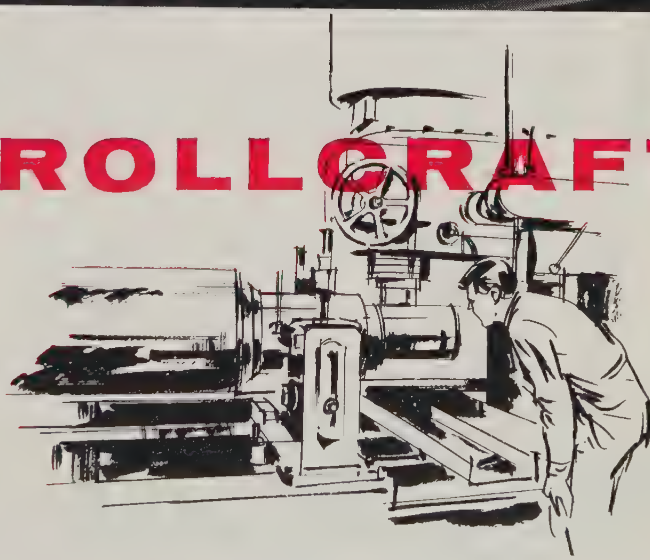

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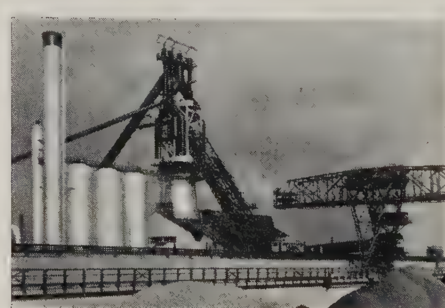

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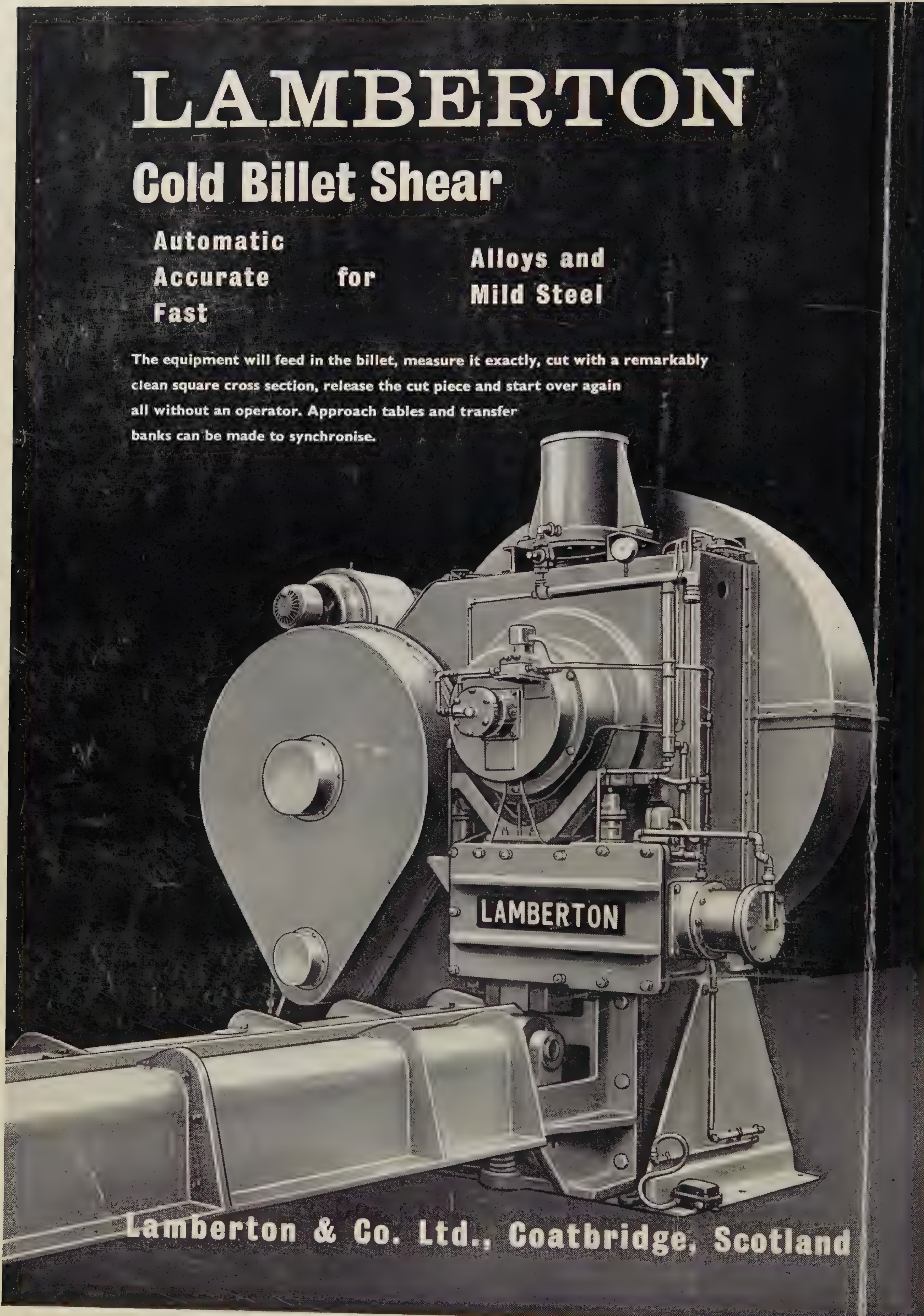
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Subject Index

NOTES

Addendum Pages 329i–340xii refer to the first twelve pages of the *Journal* for December 1961 (part 4 of this volume). Pages 329–340 appear as the last twelve pages of the *Journal* for November 1961 (part 3 of this volume).

Alloy Steels Carbon and iron are ignored and the alloying elements are arranged in alphabetical order; for example, Nickel–Chromium–Molybdenum Steel will be found under Chromium–Molybdenum–Nickel Steel

Alloys Carbon and iron, when present, are included in the title; iron, when present, is always mentioned first and the other elements follow in alphabetical order, carbon being in all cases mentioned last, for example, Iron–Silicon–Carbon Alloys and Iron–Chromium–Nickel–Carbon Alloys.

Name Index

NOTES

Addendum Pages 329i–340xii refer to the first twelve pages of the *Journal* for December 1961 (part 4 of this volume). Pages 329–340 appear as the last twelve pages of the *Journal* for November 1961 (part 3 of this volume).

Names with prefixes will be found under the initial letter of the prefix, the prefix and the remainder of the name being considered as one word for alphabetization.

Double-barrelled surnames are indexed under the first name of hyphened names, and under the second name of unhyphened names.

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